THE CANADIAN ANAESTHETISTS' SOCIETY JOURNAL

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JOURNAL DE LA SOCIÉTÉ CANADIENNE DES ANESTHÉSISTES

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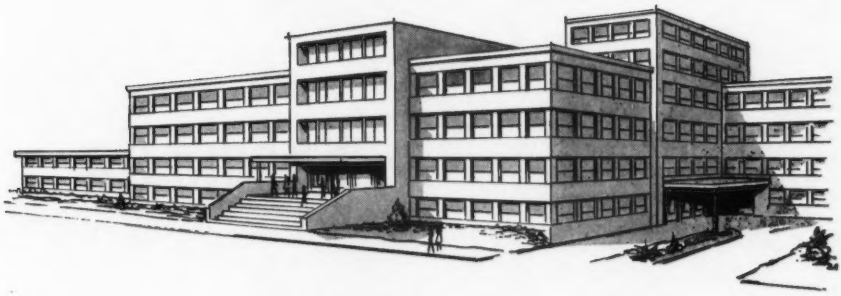

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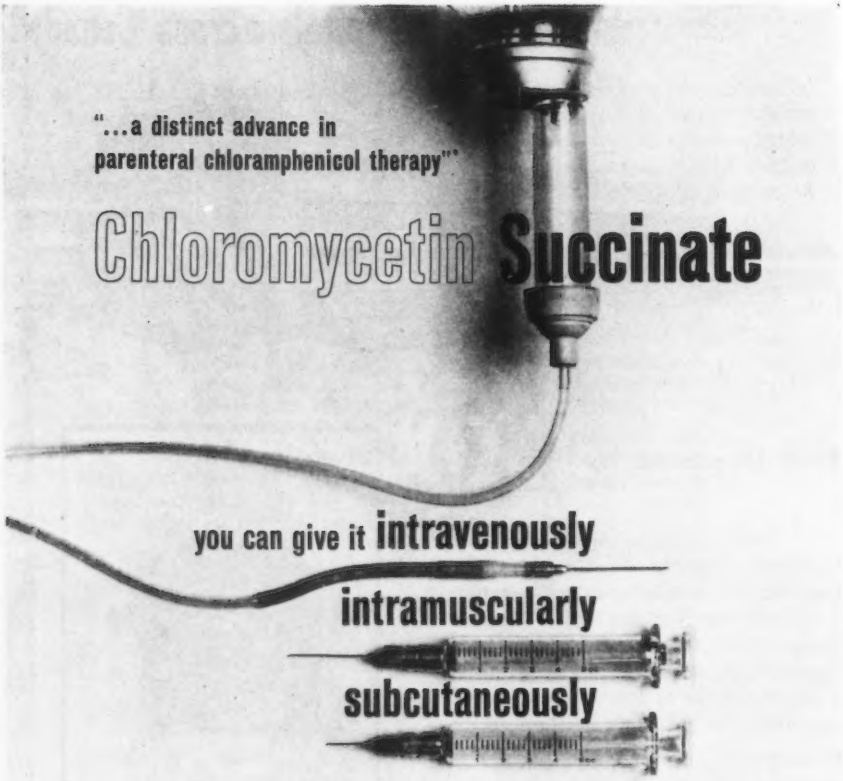

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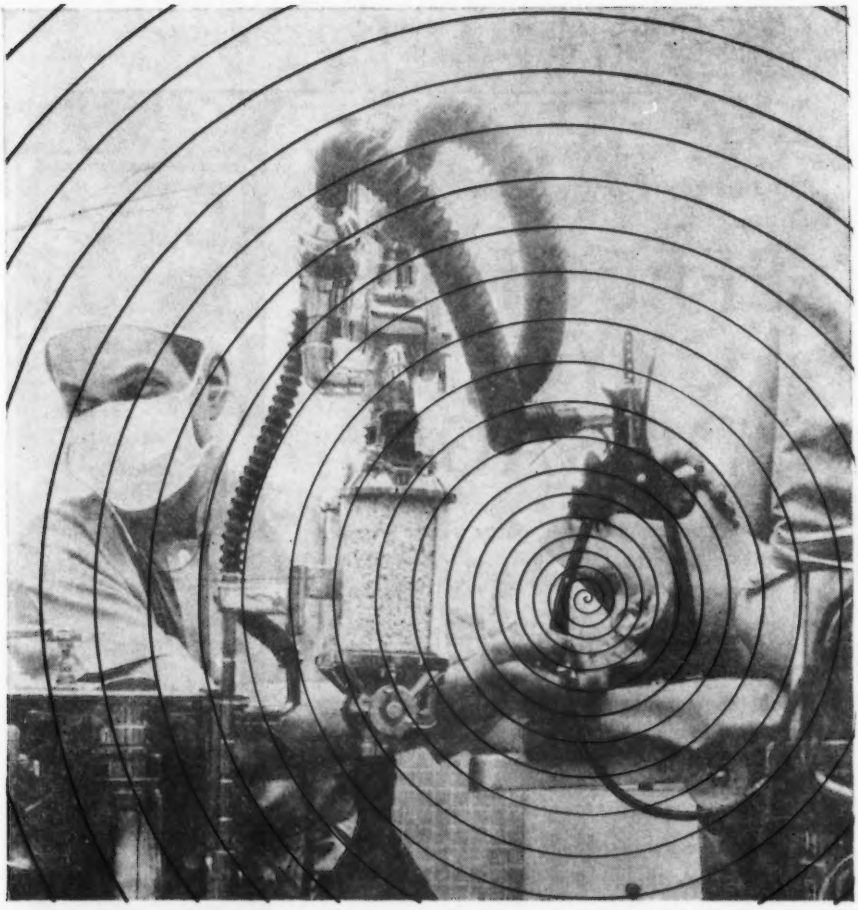

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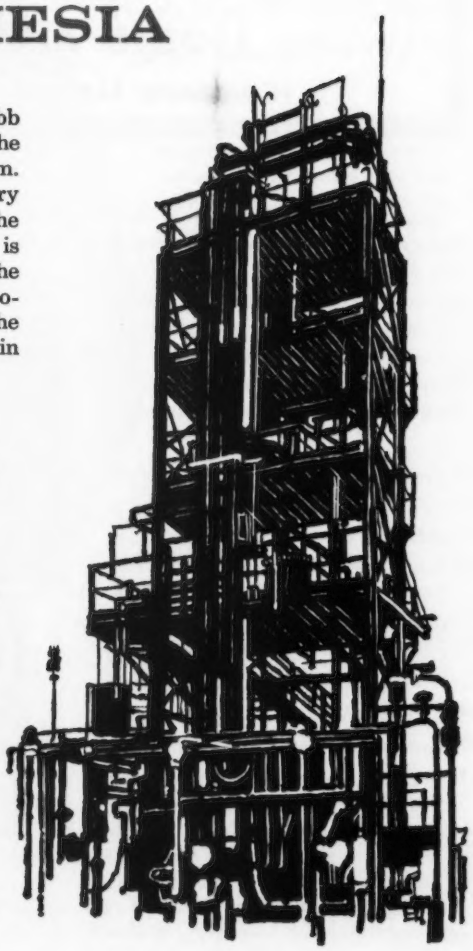

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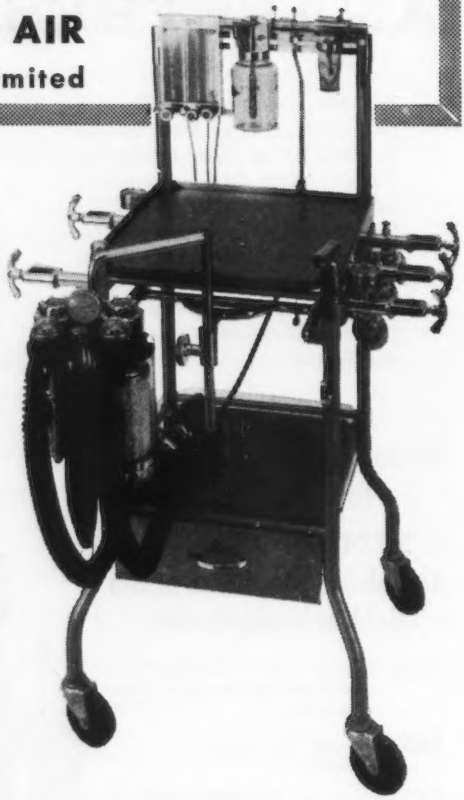

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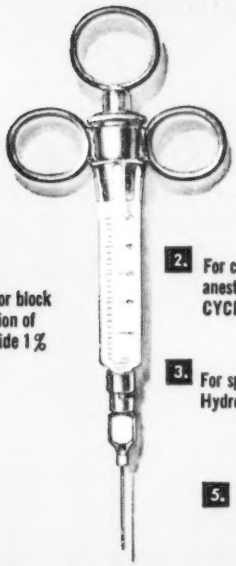

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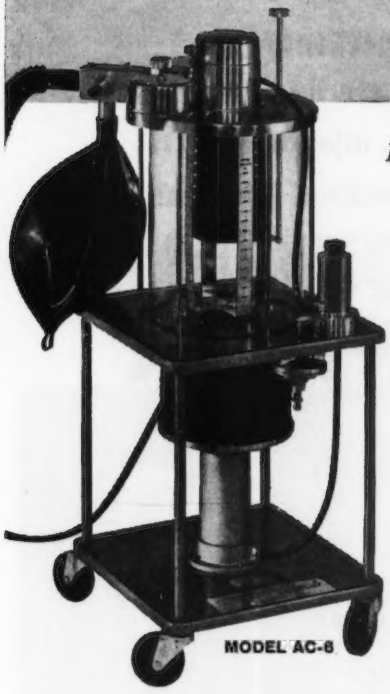

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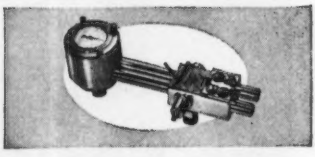

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ADDRESS OF THE PRESIDENT*

YOUR PRESIDENT and the officers of the Canadian Anaesthetists' Society take great pleasure in welcoming here tonight this large number of anaesthetists and their wives as well as all those others who have been good enough to honour us with their presence at our annual banquet.

I do not intend to speak to you of the first anaesthetic discoveries, of which you are all aware, but those of you who began about thirty years ago remember the meagre resources we had at our disposal during that period. You know how much courage and self-possession were necessary to undertake the sometimes risky operations with nothing but a simple mask and substances requiring delicate handling. Oxygen, solutions, transfusions, and other resuscitation procedures were not in current and preventive use and could not be obtained except in extremely dramatic and often desperate circumstances.

The anaesthetists of that time practised an art rather than a science, as is made evident by a glance at the number of volumes published then which were entitled "The Art of Anaesthesia." One had to be content with very general medical knowledge because textbooks on anaesthesia were scarce and elementary. Constant observation of the patient, the known indications of the degree of anaesthesia, and the fruits of long and precious experience supplemented the scientific refinement of anaesthetists.

As the years went by, we witnessed the discovery of more powerful gases, handy barbiturates, extremely precious curares, simplified methods of transfusion, potentialized anaesthetics with controllable hibernation, more and more varied and perfected equipment, and the manipulation of all these products and instruments requires an increasingly thorough and broad knowledge on the part of the anaesthetist.

The rapid evolution of the teaching of anaesthesia came about in Canada thanks to a few pioneers who helped the earlier anaesthetists to profit by their clinical experience; thanks to our universities which put their scientists and laboratories at our disposal in order to teach basic sciences and experimental medicine; and thanks also to our hospitals which furnished us with material that was extremely precious in the practical application of the teaching of theory.

As you see, the anaesthetists of Canada proved equal to the task since they have succeeded in training a great number of competent anaesthesists to answer the needs of our hospitals, and furthermore, several of our former students have been called abroad to fill important appointments in teaching and organizing departments of anaesthesia in those regions where this specialty was not yet making much progress.

Because of the success of Canadians abroad and the prestige of some of our own members, the World Federation of Societies of Anaesthesiologists will hold its next congress in Toronto in 1960 and has honoured one of our members by electing him president. I, therefore, take advantage of this opportunity to solicit

*Presented at the Annual Dinner of the Canadian Anaesthetists' Society, May 6, 1959.

your complete collaboration to make this congress a success, and I urge those who will get the chance to go to Scotland this summer to extend a cordial invitation to our European colleagues. This will be an excellent occasion to show foreigners that an exchange of ideas between two ethnic groups of different language and culture has been a source of scientific enrichment for our anaesthetists.

Without wishing to prolong this address, I should like to call to mind Dr. Roméo Rochette. His death has caused deep regrets and has deprived our Society of a devoted servant. He was a constant, active participant in all our congresses and was one of the pioneers of anaesthesia in French Canada. All those who knew him remember him as a faithful servant and a perfect gentleman. Let us extend our deepest sympathy to Mrs. Rochette.

We have also heard with great sorrow of Dr. F. H. Wilkinson's death, formerly Chief of the Anaesthesia Department of the Royal Victoria Hospital in Montreal. He has been an active member of our Society and was a former president of the Quebec Division. Two other members from our Province, Dr. R. Laurendeau and Dr. A. Legendre, have passed away during the past year.

In conclusion, I should like to thank all the executive members for their excellent spirit of collaboration and also our devoted secretary, Dr. R. A. Gordon, and his daily helpmate, Miss E. R. Campbell. I should also like to express my gratitude to the eminent lecturers for presenting papers of great scientific value, to the chairmen of the sessions, to the various committee members who worked behind the scenes, and to all those who took active part in the discussions. Last but not least, we must not forget the exhibitors who gave valuable assistance, the authorities of the Seigniory Club, the personnel, all members of the Society who participated in this congress, and all those far and near who have contributed to the progress of our Society.

Now it gives me great pleasure to introduce to you the man whom you have so ably chosen to direct the destiny of our Society in the course of this coming year. His numerous publications, his spirit of organization, and his aptitude for teaching have made us appreciate him. He has successfully fulfilled various functions in our Society and is also Professor of Anaesthesia at the University of Alberta. His past, his experience, and his thorough knowledge of the functioning of our Society guarantee the effective administration of our association.

Without further ado, I have the honour to introduce your new President: Dr. E. A. Gain, from Edmonton, Alberta.

EUGÈNE ALLARD, M.D.

ALLOCUTION DU PRESIDENT*

VOTRE PRÉSIDENT et les officiers de la Société Canadienne des Anaesthésistes sont heureux de saluer ce soir un aussi grand nombre d'anesthésistes et leurs épouses ainsi que tous ceux qui ont bien voulu nous honorer de leur présence à notre diner annuel.

Je ne vous parlerai pas des premières découvertes anesthésiques que vous connaissez tous, mais ceux qui ont fait leur début il y a environ trente ans se rappellent comment étaient maigres les ressources que nous avions à notre disposition à cette époque. Ils savent comment il fallait d'audace et de possession de soi-même pour entreprendre avec un simple petit masque et des substances d'un maniement très délicat des interventions parfois hasardeuses. L'oxygène, les solutés, les transfusions et les autres procédés de réanimation n'étaient pas d'usage courant et préventif, mais ne pouvaient être obtenus qu'en présence de circonstances exceptionnellement dramatiques et souvent désespérées.

Les anesthésistes de ce temps pratiquaient plutôt un art qu'une science comme on peut en juger par le nombre des volumes publiés à cette période et qui s'intitulaient l'"Art de l'Anesthésie." On devait se contenter de connaissances médicales très générales car les traités d'anesthésie étaient rares et élémentaires. L'observation constante des malades, des signes connus de la profondeur de l'anesthésie et le fruit d'une longue et précieuse expérience suppléaient aux raffinements scientifiques des anesthfflsistes modernes.

Au fur et à mesure que les années se sont écoulées, nous avons vu apparaître des gaz plus puissants, des barbituriques très maniables, des curarisants excessivement précieux, des procédés de transfusions simplifiés, des anesthésies potentialisées avec hibernation contrôlable, un outillage de plus en plus varié et perfectionné dont la manipulation de tous ces produits et instruments nécessitent de la part des anesthésistes des connaissances de plus en plus approfondies et universelles.

Cette évolution rapide de l'enseignement de l'anesthésie s'est accomplie chez nous grâce à quelques pionniers qui ont fait bénéficier les plus jeunes de leur expérience clinique, grâce à nos universités, qui ont mis à notre disposition leurs hommes de science et leurs laboratoires pour l'enseignement des sciences de bases et de la médecine expérimentale et grâce à nos hôpitaux qui nous ont fourni un matériel excessivement précieux à l'application pratique de cet enseignement théorique.

Comme vous le voyez, les anesthésistes du Canada n'ont pas failli à la tâche puisqu'ils ont réussi à former un très grand nombre d'anesthésistes compétents qui répondent aux besoins de nos hôpitaux et même plusieurs de nos anciens élèves ont été appelés à l'étranger pour occuper des postes importants dans l'enseignement et l'organisation des services d'anesthésie dans les régions où cette spécialité était encore assez peu avancée.

*Presenté au Diner Annuel de la Société Canadienne des Anesthésistes, le 6 mai, 1959.

C'est grâce à notre rayonnement à l'étranger et à la valeur et au prestige de quelques uns des nôtres que la Fédération Mondiale des Sociétés d'Anesthésie tiendra son prochain congrès à Toronto en 1960, et qu'elle a honoré un des nôtres en le choisissant comme président.

Je profite donc de cette occasion pour solliciter votre plus entière collaboration au succès de ce congrès et que tous ceux qui autont l'occasion de se rendre en Ecosse cette été invitent cordialement nos confrères européens. Ce sera une excellente occasion de démontrer aux étrangers que nos échanges d'idées entre deux groupes ethniques de culture et de langage différents ont été une source d'enrichissement scientifique pour nos anesthésistes.

Sans vouloir trop prolonger cette allocution, permettez-moi de rappeler à votre souvenir le nom du Dr Roméo Rochette. Sa disparition a causé de vifs regrets et notre société perd un de ses dévoués serviteurs. Il a toujours participé activement à tous les congrès et a été un des pionniers de l'anesthésie au Canada français. Tous ceux qui l'ont connu gardent de lui le souvenir d'un loyal serviteur et d'un parfait gentilhomme. Réitérons à Mme Rochette nos plus sincères sympathies.

Nous avons aussi appris avec tristesse le décès du Dr. F. H. Wilkinson de Montréal. En plus d'avoir été chef du service d'anesthésie de l'Hôpital Royal Victoria, il fut toujours un membre très actif de notre société et un ancien président de la Division de Québec. Nous déplorons aussi la mort du Dr R. Laurendeau et du Dr A. Legendre, tous de la province de Québec.

En terminant, je veux remercier tous les membres de l'exécutif pour leur excellent esprit de collaboration et aussi notre très dévoué secrétaire, le Dr R. A. Gordon, et sa collaboratrice de tous les jours, Mlle E. R. Campbell. Je dois aussi exprimer ma reconnaissance aux éminents conférenciers qui ont présenté des travaux de haute portée scientifique, aux présidents des séances, aux membres des différents comités qui ont travaillé dans l'ombre et à tout ceux qui ont pris part active aux discussions. Il ne faut pas non plus oublier les exposants qui nous ont apporté un concours très précieux, les autorités du Seignory Club, le personnel, tous les membres de la société qui ont participé à ce congrès et tous ceux qui de près ou de loin ont contribué au progrès de notre société.

Il me reste maintenant le devoir très agréable de vous présenter celui que vous axez judicieusement choisi pour diriger les destinées de votre Société au cours de l'an prochain. Il fut apprécié pour ses nombreuses publications, son esprit d'organisation et ses aptitudes pour l'enseignement. Il a rempli brillamment de nombreuses fonctions dans notre Société et est aussi professeur d'Anesthésie à l'Université de l'Alberta. Son passé, son expérience et sa connaissance parfaite du fonctionnement de notre Société sont une garantie pour la bonne administration de notre Association. J'ai donc l'honneur de vous présenter votre nouveau Président: le Dr E. A. Gain, d'Edmonton, Alberta.

EUGÈNE ALLARD, M.D.

ARTIFICIAL RESPIRATION AND RESPIRATORS[1]

J. G. ROBSON, F.F.A.R.C.S.[2]

IT WAS REALIZED in the eighteenth century that persons who had apparently drowned might be resuscitated by the "Elijah" method of mouth-to-mouth insufflation, but it was not until the nineteenth century that artificial respiration was thought to have any important part in the treatment of these people. It is perhaps rather more surprising that until about ten years ago the administration of oxygen was considered to be much more important than the achievement of ventilatory adequacy in a wide variety of diseases which cause partial respiratory failure.

Advances in respiratory physiology and pathology have now brought our knowledge of artificial respiration and the indications for its use to a reasonably sophisticated level, and technical improvements in apparatus have matched these advances. In fact, workers in the technical field have been outstanding in their ingenuity in devising machinery for artificial respiration, and the choice would appear to be difficult. Only a consideration of the basic principles will enable us to make a choice. Many of the intermittent positive pressure machines available work very well within their limited field of assistance to respiration during surgical anaesthesia, but in no way could most of them be considered suitable for the prolonged treatment of respiratory failure.

The indications for artificial respiration can be broadly divided into two categories: (*a*) where disease or injury, or drugs, prevent adequate work from being done on ventilation (for example, myasthenia gravis, head injury, and barbiturate poisoning); (*b*) where, for some reason, the work required to produce adequate ventilation is beyond the capacity of the individual (for example, in crush injury of the chest, massive infiltration of lung tissue, or postoperative mechanical impairment of respiration).

The respirator chosen has to be adaptable to the conditions present in a very wide variety of conditions.

It is accepted that, from the physiological viewpoint, there is no difference between the external suck applied to the chest wall by a cabinet type of respirator and the force exerted on the airway by an intermittent positive pressure respirator. They both achieve ventilation by raising the intrathoracic pressure. Because of their greater convenience in nursing and general management and greater versatility, intermittent positive pressure machines are now more commonly used. Cuirass respirators, rocking beds, and electrophrenic respirators are still used, but they are not within the scope of this paper.

When positive pressure is applied throughout the respiratory cycle to the airway of normal persons, the intrathoracic pressure rises, the venous return to the heart is impaired and the cardiac output and blood pressure fall. Within a few heart beats vasoconstriction occurs, the venous pressure rises to restore right

[1]This paper was presented at the meeting of the American College of Surgeons, April, 1958.

[2]Wellcome Research Department of Anaesthesia, McGill University, Montreal.

atrial filling, and the cardiac output and blood pressure return to normal. A normal person can so compensate for sustained mean pressures of about 20 cm. water. Cournand *et al.* (1) showed that the significant factor in the reduction of cardiac output during artificial respiration was the mean tracheal pressure and that any rise in this would produce these effects.

In the face of a mean tracheal pressure above atmospheric pressure, any factor which prevents an effective increase in venous pressure will prevent compensation so that cardiac output and blood pressure will fall. In the application of artificial respiration, most commonly we meet with the effects of prolonged hypoxia and carbon-dioxide retention, surgical shock with hypovoloemia and with the central failure of vasomotion, as for example in bulbar poliomyelitis. The first principle is, therefore, that the mean tracheal pressure should be kept to a reasonable minimum so that little vasoconstrictor response is demanded by the therapy itself.

When a positive pressure is applied to the airway the stretching force applied to the alveoli depends upon several factors. If the pressure is applied for sufficient time, the alveolar pressure will become equal to the airway pressure and gas flow into the lungs will cease. The effect of this applied pressure will depend upon the state of the thorax at the time. If, for example, the subject has full muscle power he could prevent any distension of his alveoli, even with very high applied pressures, by opposing the force; but if he assisted the applied pressure by inspiring synchronously with it, his alveoli could be grossly overdistended by the same pressure. If no active respiration is present, the distension of the alveoli will depend upon the over-all resistance to airflow into the lungs, elastic and non-elastic, and upon the applied pressure and its duration of application. This would be the case where the alveolar ventilation is uniform throughout the lung. In bronchospasm it is unreasonable to assume that all parts of the lung are equally affected by the spasm so that, if the applied pressure is raised to maintain ventilation in the face of bronchospasm, some alveoli served by the least constricted bronchi may be grossly overdistended while others are poorly ventilated. In reduced compliance of the lung, increasing the airway pressure to maintain ventilation is theoretically only safe if the compliance is reduced uniformly throughout the lung. It is better to increase the time allowed for gas flow into the lungs than to increase the pressure. In order to maintain the mean tracheal pressure then within reasonable limits, this increased duration of pressure application can be compensated for by the application of negative pressure during some part of the expiratory phase. Negative pressure, and by this is meant a reduction of pressure below atmospheric pressure, applied to the airway, however, by making the diameter of the bronchioles smaller, increases the resistance to the inflow of gas and it may prevent efficient ventilation of some parts of the lungs because some of the bronchioles may reach their critical closing pressure. It is then theoretically better to apply a small negative pressure for a longer duration than to apply a high negative pressure for a short time.

In normal persons breathing spontaneously, regular respiration is frequently interrupted by a deep inspiration of sigh. Physiologically this appears to be due to the need to open up areas of lung which have tended to collapse and become

underventilated during resting quiet respiration. If artificial respiration is adjusted so that the respiratory rate is normal for the individual and provides the calculated correct alveolar minute volume, then this mechanism is not simulated. Every anaesthetists is aware of the good clinical practice of fully inflating the lungs from time to time during the course of anaesthesia. During artificial respiration it is, from the viewpoint of alveolar collapse, better to slow the rate of respiration and to increase the volume for a given alveolar ventilation so that more of the lung is ventilated. The respiratory rate and tidal volume in health or in disease represents the combination of these in which the individual does least work on respiration. In artificial respiration this necessity can be ignored because the machine is doing the work. For example, if a patient required an alveolar ventilation of 5 L./min. and with a tracheostomy had a dead space of 50 cc., then he would be ventilated adequately by 20 respirations of 300 cc./min., but it would be much better from the point of view of alveolar collapse to ventilate him with 10 respirations of 550 cc./min. The machine would be doing more work but this would be of no importance, nor does it make any subjective difference.

Both pressure-cycled and volume-cycled respirators are available so that first of all we have to decide which type is most desirable. The volume-cycled machines all have a pressure blow-off valve which limits the maximum pressure to be applied to the lungs and, when used properly this has to be set to blow off at the pressure just above that which will push in the pre-set volume. They are in practice used as pressure-cycled machines. Unless the maximum blow-off pressure can be controlled in this way, this type of machine can be dangerous. The purely pressure-cycled machines are much more controllable and are to be preferred. The argument generally raised in favour of the volume-cycled type is that one can set the minute volume and that this is a comfort to the physician in control. The estimated alveolar ventilation calculated from one of the nomograms evolved for this purpose presupposes that both ventilation and perfusion of the lung are normal and in patients requiring artificial ventilation this may be very far from being the case. In artificial respiration it is better to judge the ventilation by its results than by any form of prescience. The greater versatility of pressure pattern possible with pressure-cycled machines is a decided advantage in the varying circumstances likely to be met with in practice.

In a pressure-cycled machine there are several parameters which require precise control for efficient artificial respiration in all circumstances.

(1) The rate of inflow of gas from the respirator should be controllable and variable between 5 L. and at least 60 L./min. This allows between 80 cc. and 1,000 cc. of gas to be pushed into the lungs in one second.

(2) The respirator should cycle at any pre-set pressure up to 40 cm. water pressure and should be infinitely variable within this range. The tidal volume and the duration of inspiration are, therefore, controlled by setting the flow rate and the cycling pressure at any given over-all thoracic compliance.

(3) The expiratory pause should be controllable in duration from 0.5 sec. to infinity.

(4) The transition from inspiration to expiration should be very abrupt and should occur as soon as the peak cycling pressure is reached.

(5) In the expiratory phase the airway should be open to the atmosphere through a low resistance pathway so that the tracheal pressure rapidly returns to atmospheric pressure. This is most important in the achievement of low mean intratracheal pressures.

(6) A negative pressure phase is desirable and it should be infinitely variable between 0 and 20 cm. water pressure. It must however have sufficient flow capacity to augment the expiratory gas flow. During normal expiration, gas flows from the lungs at rates of from 10 L./min. upwards depending upon the tidal volume and expiratory period. A respirator must, therefore, either function by allowing a free flow of gas out of the lungs and then applying a moderate negative pressure or be capable of sucking air out of the lungs at varying rates of flow up to 30 L./min. Of the two possible designs, the machine which first allows a free flow of gas out of the lungs and then applies a moderate negative pressure for the remainder of the expiratory period is to be preferred because it ensures that normal expiratory flow rates can always be allowed passively without having recourse to a negative pressure phase to achieve them.

(7) The machine should be capable of being triggered by the patient so that a small inspiratory effort will produce a full respiratory cycle. This feature should be adjustable so that minimal effort is required by the patient and yet not trigger on movement of the tubing. Good criteria are that it should trigger on the exertion of 1.0 cm. water pressure by the patient with a volume shift of about 10 cc. of gas. This feature will allow the machine to be used as an assister to respiration where some respiratory activity is still present.

(8) The machine should have efficient humidification of the gases going to the patient.

These considerations should allow us to choose a good machine from among the many available. The general design should also be taken into account because they have to be rugged and dependable. Finally, it should be possible to adapt the machine to anaesthetic use so that everyone in the anaesthetic department will become familiar with its use.

The necessity for artificial respiration is generally obvious, but in many patients with low respiratory reserve it can be difficult to decide. Where arterial blood pCO_2, pH, and oxygen saturation estimations are available, the decision cannot be in doubt for long, but one cannot obtain these in all centres. In general, the patients are dyspnoeic and cyanosed. Consciousness is disturbed and, depending upon their vasomotor state, there may be obvious signs of carbon dioxide retention such as vasodilatation, sweating and rise of pulse rate and blood pressure. The presence of bronchial secretions and the inability to cough them up is universal. It is a reasonable procedure when in doubt to intubate the patient under local anaesthesia and to impose artificial ventilation and, within a reasonable time to be sure that you are or are not improving the situation.

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THE SELECTION OF A MECHANICAL VENTILATOR

H. Barrie Fairley, M.B., B.S.(Lond.) F.F.A.R.C.S.(Eng.)[1]

Mechanical ventilating machines are being used in increasing numbers for the maintenance of respiration both in the operating room and in the treatment of respiratory insufficiency. On the North American continent and in Europe, the wide selection of available machines demands a full appreciation of the pertinent factors when consideration is being given to the purchase of such equipment.

Ventilatory Adequacy

The main purpose of all equipment of this type is to produce adequate alveolar ventilation. Since $\dot{V}_A = f(V_T - V_D)$, variations in anatomical and physiological dead space will influence greatly the tidal volume necessary to achieve satisfactory alveolar ventilation at a given respiratory rate. At the start of every stroke, the dead space and the resistance must be overcome and, in consequence, it is advantageous to deliver high stroke volumes at a relatively slow rate. This is especially the case where there is an increased dead space (for example, as in emphysema or cases with copious sputum)[2] and it is felt that intermittent positive pressure (I.P.P.) machines should be capable of delivering over 1,000 ml. per stroke, in a short period. To do this efficiently, delivery rates of 40–60 l./min. will be required during inspiration (2).

Airway Pressures

At the end of the inspiratory phase, the peak airway pressure will rise to a level dependent upon the sum of the elastic and non-elastic resistance (3). Cournand and his associates have provided the classical work (4) on optimum airway pressure wave form during the respiratory cycle, using intermittent positive pressure respiration (I.P.P.R.). The aim is to produce the lowest possible mean intrathoracic pressure and this is best achieved by a swift inspiratory phase, an immediate fall in pressure to zero and a pause. Recent investigative work, in many centres, suggests that high velocity inflation may give uneven ventilation and a consequent rise in physiological dead space, particularly in certain pathologies with varying intrapulmonary resistances, for example, emphysema. Thus, on such occasions, the ability to lengthen the inspiratory phase may be useful. However, in normal circumstances with I.P.P.R. the expiratory phase and the respiratory pause should, together, be twice as long as the inspiratory phase. It is generally agreed that the fall in venous return is minimal, using the Cournand type III wave form, as described above. The efficiency with which certain machines achieve this wave form is discussed by Saklad *et al.* (5).

[1]Department of Anaesthesia, University of Toronto and Toronto General Hospital.

[2]Recently a patient in the Toronto General Hospital Respiratory Unit (1), with bilateral pneumonia and a bronchopleural fistula, required stroke volumes considerably in excess of 1,000 ml. to maintain a normal arterial pCO_2.

Adequate stroke volumes will usually be achieved with pressures of 15–20 cm. H_2O, but the occasional necessary use of higher inflation pressures need not cause great anxiety as this may not be associated with high transalveolar pressures. Thus, in many such instances (for example, bronchospasm) much of the positive pressure may be dissipated in traversing a high tracheo-alveolar gradient.

The Negative Phase

The negative phase is likely to be of definite value on only two occasions: (1) rare instances where the systemic blood pressure falls with I.P.P.R. (occasional cases with hypovolaemia (6)—especially those associated with a low lung-thorax compliance—would fall into this group); (2) occurrences of low lung volumes, for example, following pulmonary resections (7). In both instances, the negative pressure permits increased tidal exchange without high positive pressures. In the second instance this may be the only way of achieving an adequate tidal exchange. It is of note that the increased likelihood of hypovolaemia during major surgery suggests a greater need for the negative phase in machines used in operating rooms, as opposed to those used for treating respiratory insufficiency.

The possibility of collapsing weakened bronchioles with negative airway pressures—thus increasing air trapping—is always present in the emphysematous patient (8). This situation is most easily produced by a rapid swing from positive to negative phase. Thus, if used at all in such cases, it has been suggested that it may be useful to apply a small negative pressure in the latter part of expiration (for example, the last third of the respiratory pause) (9). It has been shown by Opie and his associates that the introduction of a negative phase does not necessarily improve expiratory flow in the emphysematous patient (10).

Types of Machines

These fall into two broad groups (11): (i) volume constant–pressure variable machines; (ii) pressure constant–volume variable machines.

Volume Constant–Pressure Variable Machines

These machines have an obvious advantage in providing a constant predetermined amount of ventilation. In consequence, they are of particular value in patients presenting varying resistances to inflation: in the operating room—for anaesthesia using intermittent intravenous doses of muscle relaxant, thoracic surgery, patients with varying degrees of bronchospasm or copious sputum being suctioned intermittently; in the treatment of respiratory insufficiency—the same advantages obtain and it might be noted that there is a special advantage here in the treatment of tetanus and in patients with considerable sputum.

These machines are set to deliver a constant tidal volume and do so in the face of widely varying resistances (5, 11). They are usually equipped with an adjustable blow-off valve, which one may set to blow off at whatever is considered to be the maximum safe airway pressure. The latter is much higher than is commonly believed and is, perhaps, in the region of 50 cm. H_2O in the normal person

and may be higher in certain pathological states. However, in emphysema the varying intrapulmonary resistances may cause very high transmural pressures to be applied in the region of the more diseased alveoli. Thus, in patients with bullae or air cysts, the maximum safe pressure might be lower.

Pressure Constant–Volume Variable Machines

These machines are set solely to achieve a constant pressure on inflation. They suffer from the disadvantage that, at a given pressure, the tidal volume varies with changes in resistance. Thus, at a given airway pressure setting, changes in sputum volume and position will vary alveolar ventilation from moment to moment. Differences in elastic resistance from patient to patient (and even in the same patient, for example, with tetanus, intermittent relaxants, etc.) will produce varying alveolar ventilation. Thus, a constant ventilation cannot be ensured with these machines although in many instances it is achievable (for example, in patients with normal lungs having a lower abdominal operation or suffering from barbiturate intoxication; however, even in the latter, changes in posture will cause varying ventilation).

Volume-limiting machines. A few pressure constant machines are fitted with a device which prevents the bellows excursion going beyond a certain adjustable point. Thus, by setting the pressure higher than is necessary, the bellows can be set to deliver only a certain volume. This is a variation on the volume constant theme, in effect. However, many of these machines are not fitted with valves and pressure gauges with high enough ranges to permit constant ventilation against high resistance.

Motive Force

Ventilating machines are nearly all activated by either compressed gas (air, O_2, etc.) or an electric motor.

Compressed gas. These machines function either as intermittently opening adjustable reducing valves—the motive force being also the inflating gas—or have their own circuit, separate from the motive force. The former is used in respiratory therapy and the latter in the operating room. These machines have the disadvantage of requiring a large tank of compressed gas (in most instances), unless sufficient line pressure is available from a wall oxygen supply. The cost of compressed air and of oxygen being comparable, there is little to choose between them as a motivating force.

Electric motor. Many highly efficient machines run from an electric motor which, of course, must be explosion-proof. These machines are either of type (*b*) or (*c*) (below).

Machine Circuits

Most commercially available machines fall into one of three groups: (*a*) the intermittently opening reducing valve, as mentioned above; (*b*) the electrically driven piston, drawing in room air and then delivering this to the airway by a system of non-return valves; (*c*) machines consisting of a rebreathing bag or

bellows in a chamber. The bag is in continuity with a circuit to the patient and pressure is applied intermittently to its exterior, by blowing air into the chamber. This is the group commonly seen in the operating room.

Additional Features on Certain Machines

Although the basic requirement is to maintain adequate alveolar ventilation, certain special features are of some assistance in achieving this end.

Operating Room Machines

(*a*) *Separate patient circuit.* Clearly, this is important in the operating room as a means of maintaining anaesthesia.

(*b*) *Flow adaptability.* Certain machines of this type function most satisfactorily with a specific flow of gases running and are unable to function with very high or very low anaesthetic gas flows. Flexibility in this regard is most important.

(*c*) *Automatic refilling.* In machine type (*c*) (above), when the reservoir bag/bellows empties, the pressures applied to its exterior will be ineffectual and this situation may arise undetected. At least one machine has an automatic device whereby the bag is automatically refilled at this point.

(*d*) *Alternative hand ventilation.* For those of us whose appreciation of the patient's status is largely dependent upon the "feel of the bag," it is important that the manual alternative should be of the type which will give us that appreciation. Thus, on some machines the alternative is a concertina and in others an ordinary rebreathing bag.

(*e*) *Connections to the patient.* If this is one straight corrugated rubber tube, which is to be attached to the circle of an anaesthetic machine, there will be a considerable length of expansile rubber in the system. One machine can be connected directly to the patient by its own circle, containing non-return valves. However, this machine, together with at least one other, requires an absolutely air-tight circuit to function satisfactorily. Thus, one should examine the means by which one attaches the machine to the patient.

(*f*) *Noise.* Occasionally, the noise of these machines will prove irritating to the surgeon and this factor should be taken into consideration before purchasing.

Respiratory Therapy Machines

(*a*) *Long-term reliability.* Since these machines sometimes have to run for weeks on end, it is essential that they should not be temperamental. It is now an established fact that certain machines have a very satisfactory record in this regard.

(*b*) *Simplicity.* Since patients will be left in the care of nurses while entirely dependent on this equipment, it is essential that the nurses should be able to understand their mode of action and how they may be adjusted. Thus, the more complicated machines should probably only be used in special units with a permanent, trained nursing staff (1).

(*c*) *Patient-triggering mechanism.* Many machines are capable of being activated by the patient although the indications for this are not yet certain. Some machines are built purely for this purpose while others can be switched to automatic control, should the patient's initiation become inadequate. Yet a third group will switch to automatic control and back again—spontaneously—depending on the patient's respiratory efforts. All patient-triggered machines deliver a positive pressure phase in response to the patient's creating a small negative airway pressure. This is either set to fire off at, say, −2 cm. H_2O or may be adjustable (down to 0.5 cm. H_2O).

(*d*) *A means of monitoring.* Gross ventilatory deviations from normal may be produced by these machines and therefore a means of measuring tidal volume must be on hand. Thus, there should be some means of passing expired air into a gas or ventilation meter. Certain of the machines, possessing complex expiratory valves of their own, do not readily lend themselves to this. In others, it is possible to insert a non-return valve near the airway, thereby collecting expired gas in a meter. Certain types of patient-triggered equipment are difficult to monitor as are others with a negative phase.

(*e*) *Humidification.* Adequate humidity in the inspired air is most important in long-term cases. Certain machines have a humidifier built in, but those which do not can be made to deliver their inflating medium through a separate "humidifying box." Ideally, this should be thermostatically controlled.

(*f*) *Inflating gas.* High concentrations of oxygen for prolonged periods being inadvisable, most machines can dilute the oxygen with air (usually in set amounts down to 40 per cent O_2) or will deliver room air alone (to which oxygen may be added).

(*g*) *Warning devices.* These are fitted to certain of the electrically operated machines and may be a light or a bell. They may show either (i) too little pressure (e.g., a leak in the circuit or a power failure) or (ii) too much pressure. In the latter instance, this can be used to indicate an increase in airway resistance. Thus, if it is found that adequate ventilation is achieved with a volume constant machine by a pressure of x cm. H_2O, then the blow-off valve can be set at $x + 5$ cm. H_2O. If the warning light is linked to the blow-off valve, then a lobar collapse, collection of secretions, tetanic spasm, etc. will be indicated by its going into action.

All Machines

(*a*) *Pressures required.* Normally, positive pressures in the range 12–20 cm. H_2O will achieve adequate ventilation (although lower pressures should be available if paediatric therapy is contemplated). Positional changes (e.g. Trendelenburg) may require this to be increased and occasional cases with a high resistance may require pressures up to 60 cm. H_2O. This is most extreme but may be seen in occasional cases of respiratory insufficiency.

(*b*) *Negative phase.* Negative pressures up to −15 cm. H_2O may be useful on occasion, as mentioned above. They are more frequently of use in machines for operating room use.

(*c*) *Phase ratio variability.* The value of varying the duration of the separate phases of respiration has been discussed in many publications and is certainly of occasional use. The advantages of this facility must be set against the added complication which the additional knobs provide for the attendant staff. In principle, the concept should be "Use the simplest machine which will do the job."

(*d*) *C.S.A. approval.* On any *electrically-operated* equipment, this is of course essential and it is of interest that certain excellent and well-proven machines are not available in this country because their electrical equipment is not of the required standard.

(*e*) *Built-in manometer.* This would appear to be an invaluable accessory which is not available on some machines (one—the Mörch Piston Respirator—because it is designed to run with high flows and an uncuffed tube—possesses neither manometer nor blow-off valve). It is important to realize that neither pressures nor volumes measured at the machine are the same as in the airway itself and, if absolute measurements (as opposed to an indication of a change) are required, they must be carried out at or very near the airway.

(*f*) *Built-in spirometer or gas meter.* This is a feature of volume-controlled machines, *ipso facto.* However, certain pressure constant machines possess a ventilation meter in the circuit and this is most useful (a reduction in volume indicating an increase in resistance, for any of the reasons mentioned above). It is necessary to check these meters, from time to time, of course.

(*g*) *Built-in suction.* This is provided as a part of certain units.

Summary

(1) An attempt has been made to discuss the elementary physiological requirements of a mechanical ventilator.

(2) The types of machine available are grouped and it is shown that volume constant–pressure variable machines provide the most satisfactory ventilation.

(3) The motive forces used and the machine circuits are described in outline.

(4) Special features available on (*a*) operating room machines and (*b*) respiratory therapy machines are described.

(5) A table is appended, showing certain of the features available on many machines.

Résumé

La popularité croissante de respirateurs mécaniques dans les salles d'opérations et dans le traitement de l'insuffisance respiratoire exige une connaissance approfondie de différents facteurs. (1) Ventilation: l'appareil doit pouvoir fournir un volume inspiratoire de plus de 1,000 cc. en un temps, au cas où l'on serait en presence d'un espace mort très élevé. (2) Pression dans l'arbre respiratoire: la courbe, III, de Cournand, est idéale. Elle produit une insufflation rapide, le retour au zéro de pression est immédiat et suivi d'un arrêt. La durée de l'expiration et de l'arrêt doit être le double de celle de l'inspiration. Une pression negative peut être utile en cas d'hypovolémie ou après une résection pulmonaire.

TABLE I

	Primarily for		Volume constant	Pressure constant	Motive force		Circuit type			Patient-triggered	Automatic	Switches spontaneously	Negative phase	Phase variability	Automatic bag refill	Can deliver room air	Alternative bag	Alternative concertina	Humidifier	Humidifier with thermostat	V_E easily monitored	Warning devices		C.S.A. approved	Built-in manometer	Built-in gas meter	Built-in suction
	OR*	RT†			Gas	Electric	(a)	(b)	(c)													Excessive pressure	Falling pressure				
Beaver		×	V.L.‡			×		×			×					×					×			×	×		
Bennet Resuscitator		×		×	×		×			×	×														×		
Bennett PRIA		×		×	×		×			×	×	×													×		×
Bennett Assistor	×			×	×				×	×	×		×	×			×				×				×		
Bird Mark 7		×		×	×		×			×	×														×		
Bird A/C	×		V.L.		×				×	×	×				×		×				×				×		
Blease P.3		×	V.L.			×		×		×	×	×						×			×		×	×	×		×
Other Blease Pulmoflators	×		V.L.			×			×		×		×	×				×		×	×		×	×	×		×
Emmerson A/C	×				×				×	×	×	×	×	×							×				×		
Engstrom	×	×	V.L.			×		×			×			×						×	×				×	×	
Jefferson GH3	×		V.L.		×				×		×		×	×							×				×		
Jefferson A/C	×		V.L.		×				×	×	×	×	×	×							×				×		
Monaghan Ventalung		×		×	×		×			×	×														×		
Morch Surgical	×		V.L.		×				×		×		×	×				×			×				×		
Morch Piston		×	×			×		×			×							×		×	×			×			
Radcliffe PNP		×		×		×		×			×		×									×	×		×	×	
Radcliffe Portable PNP	×	×		×		×		×	×		×		×									×	×		×		
Radcliffe IPP				×		×		×			×														×		
Stephenson CRU	×	×	V.L.		×			×	×		×		×	×				×							×		
Stephenson A/C	×	×	V.L.		×			×	×	×	×	×	×	×				×									
Van Bergen		×	×			×		×			×		×								×	×	×		×		

*OR: operating room. †RT: resuscitation therapy. ‡V.L.: volume limited.

(3) Différents modèles: il existe des appareils à volume constant et pression variable et d'autres à pression constante et volume variable. Les premiers fournissent une ventilation constante beaucoup plus facilement. On discute des différents circuits et forces motrices et on mentionne les détails suivants. L'appareil en service dans la salle d'óperation doit avoir un circuit dans lequel on peut introduire n'importe quel mélange de gaz anesthésique. On discute des avantages d'un ballon qui se remplit automatiquement et du besoin d'un appareil supplémentaire de ventilation. L'appareil dont on se sert dans le cas de depression respiratoire doit être de construction robuste, de manipulation facile, avoir un bon humidificateur, et, si possible, avoir un mécanisme que le patient peut facilement déclencher lui-même. Le volume de l'air courant doit être enregistré facilement. On discute d'autres questions. Le tableau démontre quelques-unes des qualités de certains appareils.

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THE PRACTICAL VALUE OF THE ELECTROENCEPHALOGRAM DURING ANAESTHESIA

E. A. GAIN, M.D.[1]

THE INTRODUCTION of a wide variety of anaesthetic agents, the development of many new and complex techniques, and the ever increasing magnitude of surgical procedure have so altered the practice of clinical anaesthesia that the traditional concepts of the signs of anaesthetic depth are no longer adequate or accurate. The scheme for the clinical signs of anaesthesia elaborated by Guedel (1) based upon the progressive disappearance of reflex responses, and similar schemes listing signs for intravenous agents are of little value in assessing the patient anaesthetized by modern drug combinations and techniques. It has become impossible to formulate the signs of anaesthesia for every set of circumstances now likely to be encountered, and the "semi-intuitive assessment" of the patient by such unreliable monitors as the "educated hand," and the circulatory variations are far from accurate. The need for a reliable means of accurately and continuously assessing the depth and reflex responsiveness of the patient is more important than ever before. Only the electroencephalogram provides the accurate quantitative assessment that is required, in that it provides a continuous record of the extent to which the electrical activity of the patient's brain is being affected. In this way it provides an accurate measurement of the blood level and brain depression of the patient (3). In addition the electroencephalogram promptly reveals changes in cerebral activity due to alterations in cerebral circulation or metabolism precipitated by anaesthetic complication or surgical interference. As a result, this monitor is gaining increasing acceptance and importance.

A large literature is accumulating on the use of the electroencephalogram during anaesthesia and clearly delineated patterns (Fig. 1) for the more frequently used agents have been described (2, 3, 4, 5). The electroencephalogram is based on the physiological fact that a whole mass of cortical cells discharges synchronously at approximately the same rate and for this reason the pattern is one of a recurring rhythm; whereas, if the discharge was asynchronous and at different rates, the record would consist of an irregular pattern as is seen with mental and visual activity. The resting discharge is due to the existence of a circuit between the cortex and thalamus. Impulses from the cord and cortex reach the thalamus causing the thalamus to discharge, which in turn stimulates the cortex again.

In the deeper levels of anaesthesia, the cortical potentials occur in groups separated by periods of inactivity. Stimulation of the thalamus during one of these periods can set up typical alpha waves in the cortex. These findings suggest that at the level of anaesthesia associated with periods of suppression of cortical activity, there must be a depression at some point in the cortico-thalamic circuit.

[1]Department of Anaesthesia, University of Alberta Hospital and Faculty of Medicine, University of Alberta, Edmonton, Alta.

As the cortex remains capable of responding to normal stimuli, this depression must occur at the thalamic level or below: that is, the thalamus is not capable of responding to its normal stimulus or thalamic activity is normal, but the stimuli are unable to reach it.

For purposes of anaesthesia only unilateral leads are required. Under anaesthesia the individual wide variation disappears, even in patients with abnormal patterns, which greatly simplifies the use of the electroencephalogram during anaesthesia (6). As anaesthesia deepens, an orderly progression of changing patterns occurs. These special patterns vary depending on the agent being used. They are not affected by relaxants or by opiates in usual clinical doses. Many other factors such as hypercapnia, hypocapnia, hypoxia and hyperglycemia can affect the pattern and must be excluded; nevertheless, during clinical anaesthesia as usually conducted the only significant factor is the brain content of the anaesthetic agent and the tracing obtained is directly related to the concentration of the agent in the brain (6, 7).

It is now a well-recognized fact that the clinical signs of anaesthesia lag behind the electroencephalographic levels and it is necessary to consider the phase of anaesthesia, whether it be induction, maintenance, or emergence, when interpreting the signs; this "lag phenomenon" can lead to dangerous blood levels is some poor risk patients if only clinical signs are relied on (7). This technique of monitoring was first used primarily as a research tool to obtain and maintain comparable anaesthetic levels during investigative procedures. With the introduction of cardiac surgery and the extreme care necessary to avoid overdose, which is so poorly tolerated by these patients, the value of the electroencephalogram became apparent (8).

When extracorporeal circulation was instituted, it was believed that some monitoring device was necessary to detect any serious deficiency in the cerebral circulation which could cause irreversible cerebral damage. The need for accurate monitoring of anaesthetic depth was also as essential in open-heart surgery as in closed.

We are aware that many large centres doing a large amount of this type of cardiac surgery do not use or believe that there is any need for electroencephalographic monitoring. We would agree that where possible simplicity is desirable and therefore looked into the possibility of abandoning another piece of equipment in an already overcrowded theatre. We attempted to discover to what extent it had been of help in avoiding complications or had been of value in other aspects of anaesthesia and surgery.

Overdose

As mentioned previously the clinical signs frequently lag behind the electroencephalographic levels. The clinical signs often indicate active reflex response when the electroencephalographic level indicates adequate depth for surgery (7). Evidently time is required for brain and tissue equilibrium to be reached. Similarly with emergence a waking pattern does not always mean a responsive

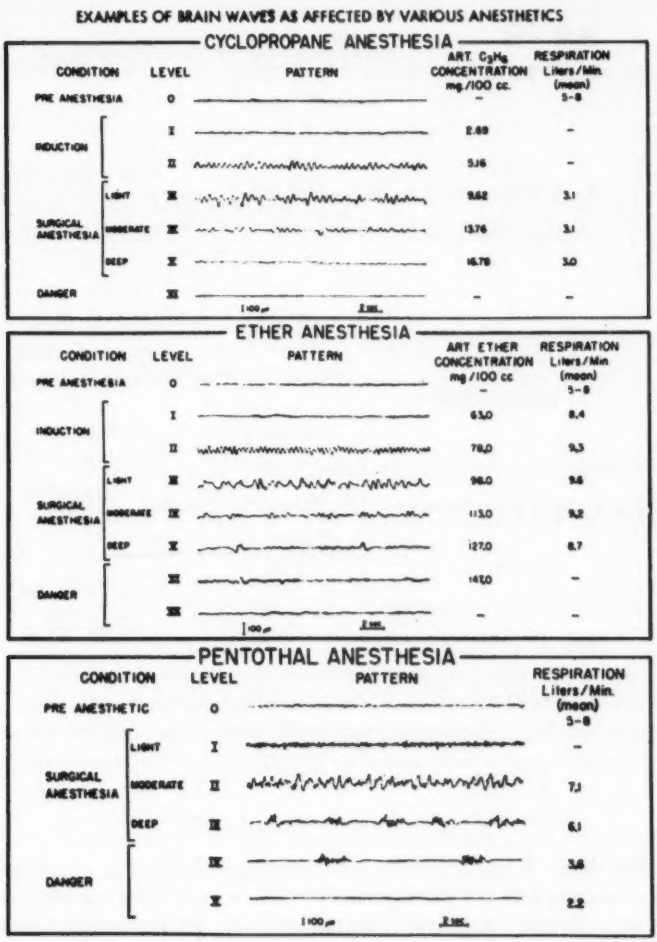
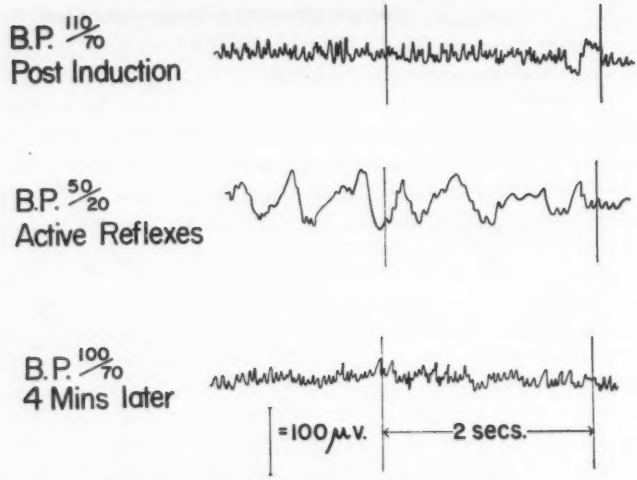


FIGURE 1

patient at the close. Because of this lag a few cases of rather sudden and severe cardiovascular depression have occurred in our cardiac work when the anaesthetist believed that the patient was in a very light plane of anaesthesia, but the electroencephalographic level was invariably too deep for this type of cardiac patient. We now believe that continuous monitoring is worthwhile in this type of case, at least until equilibrium has been achieved.

Figure 2 illustrates an electroencephalogram during induction in a case of ventricular septal defect. The patient was clinically light and reflexly responsive but had a blood pressure of 50 systolic which the resident refused to believe



Ether "Lag Phenomena" - Ventricular Septal Defect Over Dose.

FIGURE 2

was due to overdose until he was shown the electroencephalogram. With washout of the ether the electroencephalographic level returned to level 2 and with it the blood pressure. Often in infants clinical methods of blood pressure determination are very difficult or impossible to obtain, and in the poor risk infant this monitor can be very useful in protecting against anaesthetic overdose.

EXTRACORPOREAL CIRCULATION

It is in this type of work that the electroencephalograph is of most frequent help in protecting the patient against the hazards of anaesthesia and extracorporeal circulation. We have frequently seen, when using the "bubble oxygenator and sigma motor pump," that with commencement of the perfusion, after the caval catheters are clamped, rapid deterioration of the electroencephalogram occurs. Usually in these cases there is a rise in venous pressure to 15–30 mm. Hg and the head becomes very congested in appearance. If the perfusion continues, all electrical activity may cease. When this occurs, a return to normal circulation is made, the venous catheters are readjusted if necessary, and another attempt is made. As a result, it is possible that several potential cases of cerebral damage have been avoided. The usual changes seen are shown in Figure 3.

Occasionally, the very same pattern will occur but without any evidence of increase in venous pressure. In the case shown in Figure 4, a venous pressure tracing could not be obtained and congestion was not apparent. The encephalo-

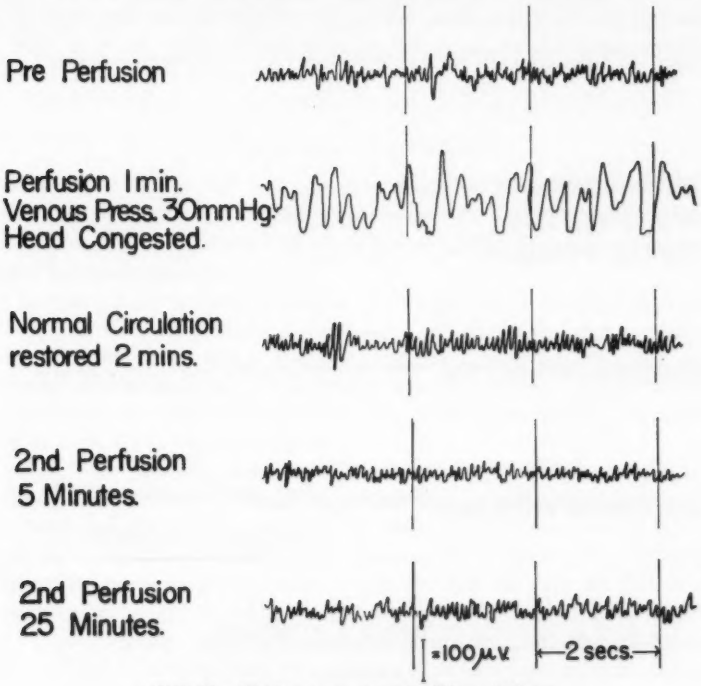
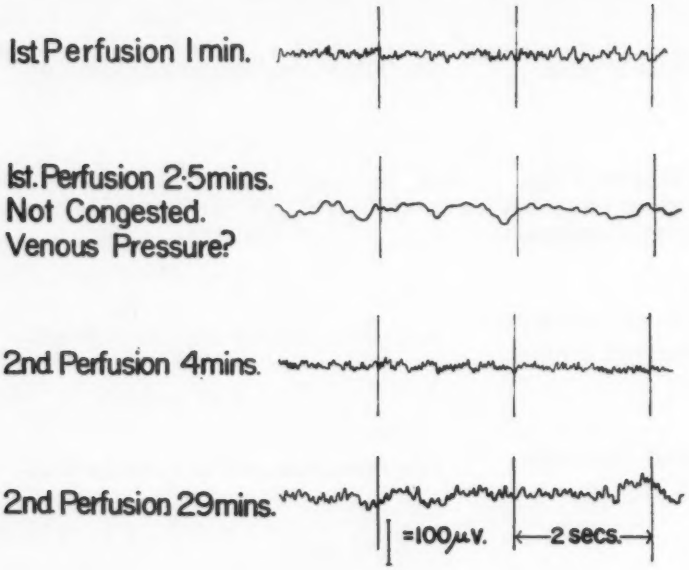


FIGURE 3

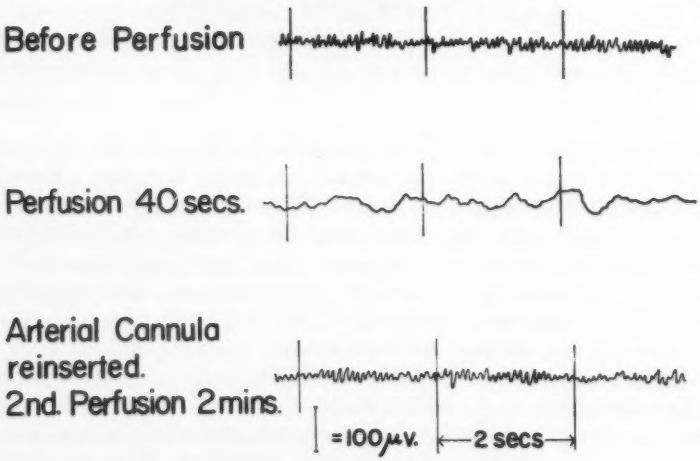
gram became abnormal soon after the perfusion commenced and the perfusion was stopped. On a second try the pattern remained satisfactory although the electroencephalographic recovery from the effects of the first perfusion was slow. We had no explanation for this case, but obviously there was a defect in the circulation, resulting in cerebral ischaemia. Since changing from the "bubble oxygenator and sigma pump" to the "disc oxygenator with non-occlusive roller pump," we have encountered a few similar cases, all of which have been corrected by increasing the arterial flow. Such inadequate flows could have been overlooked had it not been for the electroencephalograph, and cerebral damage might have occurred.

In the case shown in Figure 5, after commencement of the perfusion, the electroencephalogram rapidly deteriorated to almost complete inactivity, but the patient was very pale. An obvious diagnosis of loss of arterial flow was made and the femoral artery catheter was found to be out of the artery hidden under towels. With green drapes about the patient's head this pallor could easily have been overlooked for too long a period had it not been for the electroencephalo-



E.E.G.- Extracorporeal Circulation

FIGURE 4



E.E.G.- Extracorporeal Circulation
Arterial Cannula Lost.

FIGURE 5

gram. In this case the arterial trace was off while a blood sample was being taken. Now we insist that the electroencephalogram must be running whenever the arterial tracing is not functioning.

Controlled Hypotension

Although never a popular or frequently used technique in this country many anaesthetists must on occasion use it for neuro or plastic surgery. One of the complications, especally in the older age group, is cerebral ischaemia with post-operative cerebral damage.

Van Bergen (9) in a study of twelve cases reported four with changes in the electrocorticograms. He found a marked similarity to the electroencephalographic patterns resulting from severe hypoxia, profound hypotension, and very deep anaesthesia, and states that; "conceivably the metabolism of the cortical cells of the cerebrum virtually has ceased as a result of anoxic anoxia, stagnant anoxia or histotoxic anoxia as the case may be."

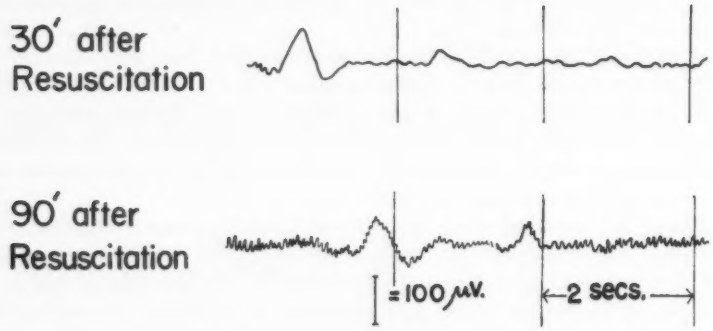
Schallek (10), working with hypotension in dogs, found profound electro-encephalographic changes which depended not only on the degree of hypo-tension, but also on the rate of fall. He believed that the rate of fall in some way influenced the body's ability to compensate by reducing the cerebrovascular resistance: the more rapid the rate of pressure fall, the less the fall in cerebro-vascular resistance. In the elderly arteriosclerotic patient, there may be little ability to compensate, regardless of the rate of fall. The only known simple clinical method of determining the adequacy of the cerebral circulation is the electroencephalogram.

Prognosis in Cerebral Anoxia

Bellville and Howland (11) have discussed the use of the electroencephalo-gram as an aid in prognosis in patients suffering from cerebral anoxia following cardiac arrest. They state that recovery without evidence of residual abnormalities is possible from almost any type or degree of electroencephalographic disorder. However, if the electroencephalographic activity has continued flat for over four hours, there is a strong presumption that this cortical damage may not be completely reversible. Even though the electroencephalogram becomes flat, if the hypoxia is corrected in less than 60 seconds, the electroencephalographic activity will return to the prehypoxic pattern promptly. There is a direct relation between the duration of the flat pattern and the time required, after correction of the hypoxia, for the electroencephalogram to return to normal.

In general Bellville states that prognosis is good if the electroencephalogram does not become flat after hypoxia, or if it becomes flat, the prognosis may be good if the fast activity is restored within one hour. The appearance of a "file pattern" carries a grave prognosis. Those patients in whom eventual recovery occurs show an initial tracing with considerable activity marked by moderate slow frequency waves of moderately high amplitude with superimposed higher frequency components (12).

Figures 6, 7, and 8 show the patterns taken after cardiac arrests with severe prolonged anoxia. In all cases a grave clinical prognosis was given, but the electroencephalographic prognosis was hopeful and all patients made a clinically complete recovery. Figure 9 illustrates the occurrence of a "file pattern" following massive arterial air embolism during open repair of a mitral incompetence. A hopeless prognosis was given and the patient died in a decerebrate state on the sixth day.



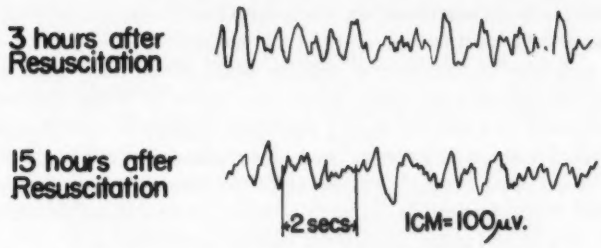
Cardiac Arrest following Haemorrhage with Prolonged Hypoxia.

FIGURE 6

Patent Ductus - severe Bronchospasm with prolonged Hypoxia and repeated (3x) Cardiac Arrest.

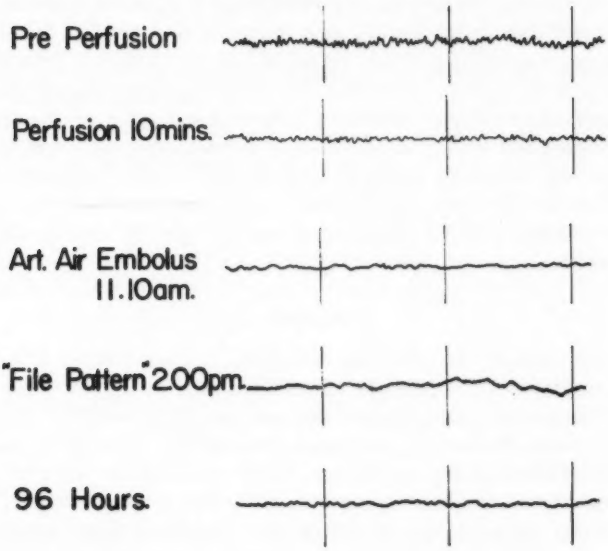
FIGURE 7

Frequently, the question is asked when cardiac arrest has occurred: is the massage effective, should it be continued? The electroencephalogram will continue to show activity as long as massage is providing adequate cerebral circulation for brain cellular metabolism. If the electrical activity disappears, then massage is ineffective and if this state of affairs continues for several minutes then recovery may be impossible (6).



Respiratory Obstruction with Cardiac Arrest.

FIGURE 8



Arterial Air Embolism.

FIGURE 9

TEACHING AID

One of the most difficult problems in teaching the resident is to convince him that the patient is in a much deeper plane of anaesthesia than is necessary for the procedure. The fear of a mobile patient and an angry surgeon is great; so the patient is frequently overdosed. This is especially so when volatile or gaseous agents are used with an apnoeic technique. Frequent spot checks with the electroencephalogram soon convince the trainee that the level of anaesthesia is much deeper than is necessary or than the clinical signs would indicate.

There are many other possible uses for the electroencephalogram during clinical anaesthesia, to mention a few: in surgery of the carotid vessels and aorta as an indicator of high carbon dioxide levels particularly during pulmonary surgery; during mitral valvotomy when the valve is being explored and repeatedly split; and as a control during analeptic therapy for barbiturate overdose.

It is our belief that we have never been given false information when monitoring anaesthetic depth and cortical activity with the electroencephalogram and that many possible complications have been avoided. It is a valuable aid in the poor risk patient, in selected types of surgery, and as a teaching aid.

Summary

Because of the inadequacy of the conventional signs of anaesthesia during anaesthesia with today's techniques and agents, it is suggested that the electroencephalogram is a useful guide in protecting the poor risk patient, particularly the cardiac patient, against overdose. This is especially so during the induction phase because of the "lag-phenomenon." Several examples of the value of the electroencephalogram during anaesthesia and extracorporeal circulation, and as a prognostic aid following cerebral hypoxia have been presented. It is also suggested that the electroencephalogram is a valuable teaching aid and that it is useful as a measure of the efficiency of cardiac massage during the treatment of cardiac arrest.

Résumé

A cause du manque de précision des signes conventionnels d'anesthésie au cours de l'anesthésie qui se pratique aujourd'hui avec les agents et les techniques modernes, l'électroencéphalogramme devient un guide précieux pour protéger les grands malades contre un surdosage éventuel de substances anesthésiques et plus particulièrement les cardiaques. Cette situation se présente surtout au cours de l'induction à cause du phénomène d'action à retardement. Nous avons donné plusieurs preuves de la valeur de l'électroencéphalogramme durant l'anesthésie, durant la circulation extra-corporelle et comme moyen de pronostic à la suite d'hypoxie cérébrale. L'électroencéphalographie s'avère également d'un précieux secours pour l'enseignement de même que pour déterminer l'efficacité du massage cardiaque durant le traitement de l'arrêt cardiaque.

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ELECTROENCEPHALOGRAPHIC WARNING OF IMPENDING LOCALIZED CEREBRAL DISORDER DURING ANAESTHESIA

MAX S. SADOVE, M.D., CECIL G. YARBROUGH, M.D.,
MEREDITH MURRAY, M.D., and DOROTHY R. BECKA[1]

DURING THE LAST TWO YEARS continuous electroencephalograms have been taken during surgical cases in an effort to correlate the changes in the brain wave patterns with the depth of anaesthesia. We have had the opportunity to study a variety of anaesthetic agents, and to observe the more or less gradual development of various critical conditions in a number of our cases. One of these we have reported (1), but the present case is basically different and of sufficient general interest to warrant a detailed description. As will be explained in the body of this report, we were able to watch the development of a localized epileptic discharge in a patient with a pre-existing neurological lesion. Apparently the anaesthetic technique and/or the operative procedure aggravated the focal disorder and precipitated the cerebral symptoms.

A retropubic prostatectomy was performed on a poor risk patient with a history of an old cerebrovascular accident. The electroencephalogram was used for purposes of study and as a control to keep the patient at an analgesic level. It has been our experience that the electroencephalogram is an excellent tool which aids the anaesthesiologist in maintaining a patient at the desired level of analgesia or surgical anaesthesia. It was during this surgical procedure that the electroencephalogram recorded a right cortical seizure fully two minutes before a left-sided Jacksonian seizure was noted clinically.

PATIENT'S HISTORY

A 67-year-old white male was admitted April 12, 1958, with a diagnosis of acute urinary retention. Physical examination revealed blood pressure of 130/75 and a regular pulse. There was a left lower facial paresis, and some deviation of the head to the left. Pupils were equal and reacted to light and accommodation. Extra-ocular movements were normal. Control of fine movements was absent in the left hand and there was residual weakness of the left side of his body. The remainder of the neurological examination gave normal findings for the patient's age. Prostate was found to be 2 to 3 plus enlarged and nodular. The electrocardiographic tracing revealed coronary insufficiency and ventricular strain. Serology was negative with blood count and urinalysis reported within normal limits. The patient had a history of hypertension and cerebrovascular accident in 1947 at which time there was a hypoaesthesia of the left side of the face. Corneal reflexes were apparent on the left. When the patient's jaw was opened, there was a deviation to the right. There was left facial droop and the tongue deviated left with some tremor. The shoulder muscles were weak on the left. Hypoaesthesia existed on the left and the deep tendon reflexes were absent that side.

[1]Division of Anaesthesiology, University of Illinois, Research and Educational Hospitals, Chicago 12, Ill.

Procedure and Findings

A Grass 8 Channel Model III Electroencephalograph was used outside the operating room door. Six solder disc electrodes were applied with electrode paste to the frontal and precentral areas bilaterally, both ears being used as a reference. A lead 2 electrocardiogram was recorded simultaneously with the electroencephalogram.

The premedication utilized was Nembutal 100 mg., morphine sulphate 10 mg. and atropine sulphate .4 mg. at 6 A.M. the day of surgery. Blood pressure prior to surgery was 116/88.

A short, control electroencephalogram was taken following preoperative sedation, but before anaesthesia was started. This record showed an irregular but symmetrical low voltage tracing (Fig. 1) which was considered to be within normal limits. It was felt that a longer wake record or a sleep record might have revealed an abnormality. The patient was given thiopental sodium 475

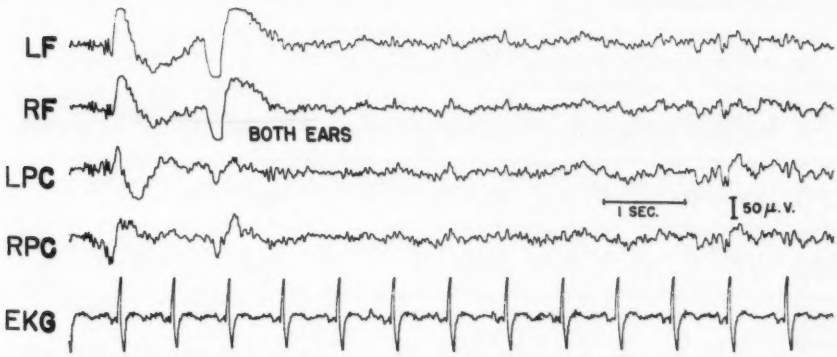

FIGURE 1. Irregular but symmetrical low voltage tracing considered within normal limits. Bifrontal eye artifacts.

mg., followed by succinylcholine 40 mg. at 8:17 A.M., intubation was performed at 8:20, and ether and oxygen, closed circuit technique, was started at 8:22 A.M. The operative procedure was started at 8:30 and the blood pressure at that time was 138/90. The EEG pattern showed a high voltage, fast, 13 to 15 per second activity with a mild amplitude asymmetry; the right frontal and on rare occasions the right precentral leads were lower in amplitude than the left (Fig. 2). This fast activity, as recorded in the electroencephalogram, is considered as the "analgesic level" of anaesthesia (2). At 8:45, a fast spike seizure discharge was noted in the right frontal area (Fig. 3). This constant seizure activity was noted in the electroencephalogram for approximately 2 minutes before the surgeon said, "The patient's left arm is vibrating," and this continued for another minute. Because of draping no other movements were noted. Attempts to deepen the plane of anaesthesia with a small amount of ether lowered the blood pressure. Figure 4 shows large slow waves in the left frontal and both precentral areas.

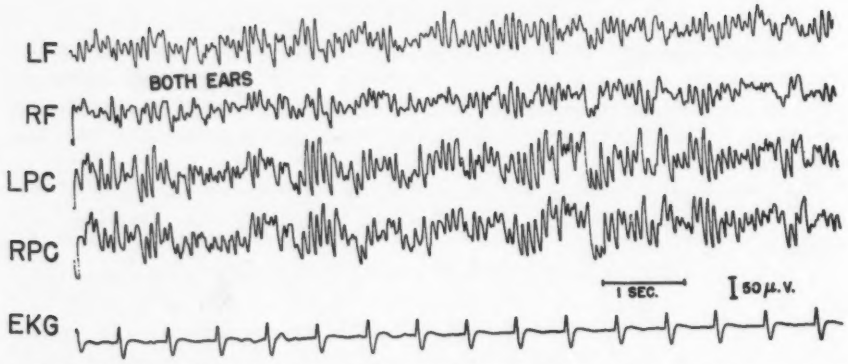

FIGURE 2. High voltage fast 13 to 15 per second activity with a mild amplitude asymmetry, the right frontal showing lower amplitude than the left. This fast activity is considered "analgesic level" of anesthesia.

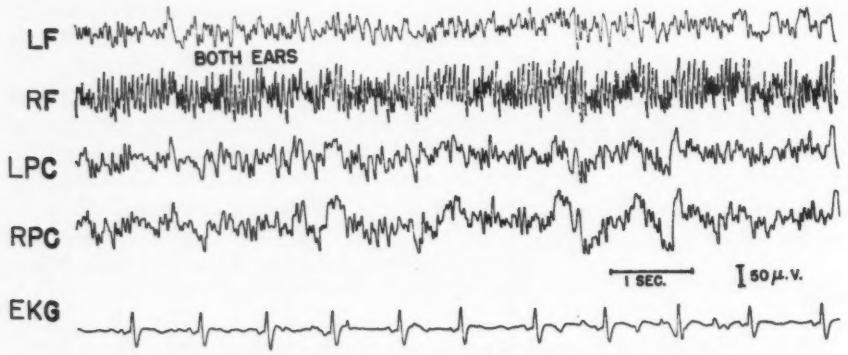

FIGURE 3. Constant fast spike seizure activity in the right frontal area.

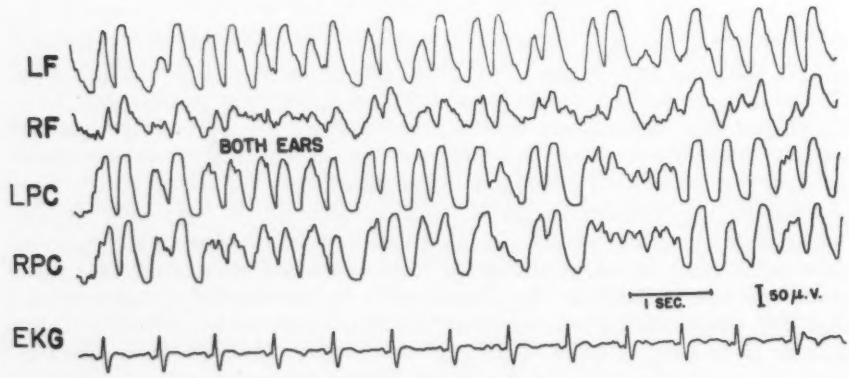

FIGURE 4. Large slow 2 to 3 per second waves in the left frontal and both precentral leads. Right frontal shows a marked depression in the amplitude and difference in frequency, possibly due to a localized post seizure exhaustion.

These patterns and this frequency (2 to 3 per second) are characteristic of the surgical level of anaesthesia (2). However, a marked depression in the amplitude and a difference in frequency were apparent in the right frontal area, possibly due to a localized post-seizure exhaustion. The patient was permitted to return to the previous analgesic level of anaesthesia (fast activity), and the electroencephalogram showed the same mild asymmetry noted in Figure 2. The subsequent surgical and anaesthetic course was otherwise uneventful and terminated at 10:25.

Postoperatively the patient developed hypostatic pneumonia. An electroencephalogram was taken one month following the surgery and showed a mild and inconstant focal slowing in the right anterior temporal–right temporal areas with occasional left temporal–left anterior temporal involvement (Fig. 5).

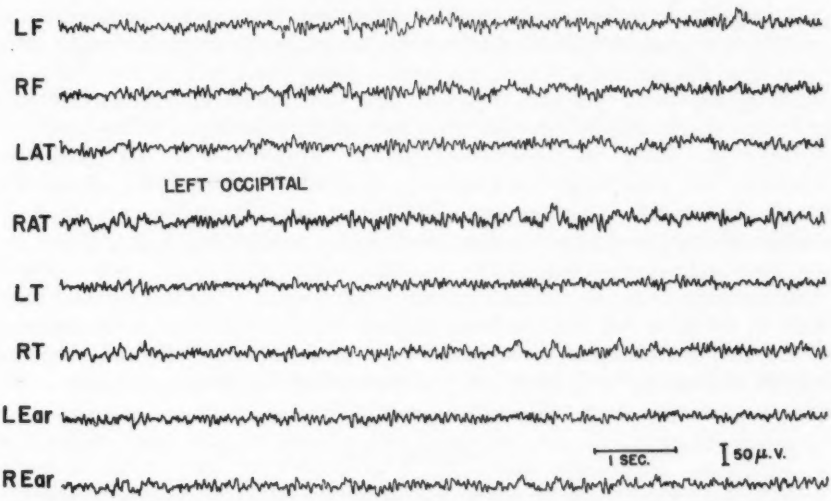

FIGURE 5. Mild focal slowing in the right anterior temporal-right temporal areas. Electroencephalogram taken one month after surgery.

A neurological examination done on June 25, 1958, approximately one month after surgery, revealed an alert and co-operative patient with a marked dysarthria, moderate left hemiparesis, greater in the upper than in the lower extremity; all deep tendon reflexes were increased in the left upper extremity and decreased in the left lower extremity as compared to the right. There was a marked left supranuclear facial paresis. Pulsations in the right internal carotid artery are definitely decreased as compared to the left. Compression of the left internal carotid artery produced a short episode of unconsciousness.

In the literature, many factors were advanced as causes and conflicting evidence was noted, with authorities incriminating the following precipitants for convulsions associated with general anaesthesia: epileptic liability (3–4), toxaemia, septicaemia, excess or deficiency of CO_2, impurities in ether and in

oxygen, deep or light anaesthesia, faulty methods of anaesthesia, hypoglycaemia, atropine, alkalosis, overbreathing, disturbance in calcium metabolism, ketosis, cerebral anaemia, cerebral injury or accident, increased cerebral blood flow, hydration of protein particles in the plasma, convulsant poisons, hyperthermia (5), hyperpyrexia and respiratory acidosis (6), or that the underlying cause was a temporary, easily reversible derangement of physiology, rather than a convulsive diathesis (7).

Comment

We have found the electroencephalogram to be an excellent tool with which to check the constancy and depth of anaesthesia. The electroencephalogram can also give important information which will illuminate the nature and give clues as to the cause of sudden or gradual deterioration of the patient's condition. This is particularly true in cases where convulsive phenomena develop during surgery or during anaesthesia. In the present case the presumption might have arisen that the patient was suffering from a generalized anoxia. The electroencephalogram shows that this was not true. The premonitory flare-up of fast spike activity in the right frontal area gave ample warning of a localized disturbance and gave the anaesthesiologist an opportunity to take protective measures. The deepening of the anaesthesia obviously stopped the seizure discharge. The question remains as to whether or not it benefited the disturbed neurons. It may have added further insult to the pre-existing injury. These are questions which we cannot answer, but they would not even have arisen and could not have been asked if an electroencephalographic recording had not been made at the time. It is obvious from this case that a single lead placement or a mid-line bipolar placement would have proven of relatively little value. In our opinion, at least one and preferably two leads should be placed over each hemisphere.

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THE EFFECT OF PERPHENAZINE ON EPINEPHRINE-INDUCED CARDIAC ARRHYTHMIAS IN DOGS: I, ANAESTHESIA WITH FLUOTHANE, AND FLUOTHANE-ETHER AZEOTROPE[1]

ALLEN B. DOBKIN, M.D.,[2] and NOEL PURKIN, B.A.[3]

A WIDE VARIETY of tranquillizer drugs have been tested clinically for preoperative medication during the past few years (1). Several of these have, in addition to an adequate sedative effect, a potent anti-emetic activity, and appear also to prevent or suppress myocardial irritability during anaesthesia (2, 3, 4).

The problem for the anaethetist has been to find the tranquillizer drug which produces the most predictable type of sedation and perhaps some anti-emetic and anti-arrhythmic effects without greatly disturbing the patient's circulation. One of the many tranquillizer drugs tested was the phenothiazine derivative, perphenazine (Trilafon®). This report deals with the effect of premedication with perphenazine on epinephrine-induced arrhythmias in dogs during anaesthesia with Fluothane and the azeotropic mixture of Fluothane and diethyl ether.

METHOD

Thirty acute experiments were carried out on twenty mongrel dogs who varied in weight from 5.5 to 15 kg. (mean, 8.0 kg.). In alternate experiments the dogs were given 0.25 mg./kg. perphenazine intravenously a few minutes preceding the anaesthetic. No other premedication was given. At least one week was allowed to elapse before an experiment was repeated on a surviving dog.

Each dog was lightly anaesthetized with a "sleep dose" of thiopental (75–175 mg.), followed by 20 mg. succinylcholine intravenously. A solution of 5 per cent dextrose in water was attached to the intravenous needle to assure adequate hydration and to keep the vein open. A cuffed orotracheal tube was placed in the trachea immediately following induction of anaesthesia. This was connected through a non-rebreathing valve, a Fluotec vaporizer, and an anaesthetic machine to a mechanical respirator. The latter was adjusted to a rate of 25–30/minutes, with volume set between 150 and 250 ml. and intermittent positive pressures to between 10 and 15 mm. Hg. Anaesthesia with nitrous oxide–oxygen (5:2) was used until the preliminary connection of a Sanborn direct writing visocardiette. In six experiments, direct femoral artery and vein pressures were measured through an indwelling catheter attached to Statham strain gauges and to a multi-channel oscilloscope with photographic recorder. In other experiments, the femoral artery cannula was attached to a mercury manometer. After control

[1]Supported in part by a grant-in-aid from Schering Corporation, Montreal, Canada.

[2]From the Department of Anaesthesia, University of Saskatchewan College of Medicine and the Anaesthesia Laboratory, Medical Research Building, Saskatoon, Canada.

[3]Medical Student Research Assistant from the University of Saskatchewan College of Medicine.

tracings were recorded, Fluothane (0.5 per cent) or the azeotropic mixture of Fluothane and diethyl ether (1 per cent) was added from the calibrated Fluotec vaporizer for approximately 25 minutes. This allowed sufficient time for an adequate and stable blood level of the primary anaesthetic and was not long enough for a possible adrenolytic action by Fluothane or the Fluothane-ether azeotrope to become dominant, as is seen with cyclopropane (5). Then l'epinephrine was injected intravenously in a strength of 0.02 mg./ml. at the rate of 1 ml./sec. to a total dose of 0.02 mg./kg. The electrocardiograph (lead 2) and blood pressure

TABLE I

EFFECT OF PERPHENAZINE ON EPINEPHRINE-INDUCED CARDIAC ARRHYTHMIAS DURING 0.5 PER CENT FLUOTHANE + N_2O:O_2 (5:2) ANAESTHESIA IN DOGS

Dog	Weight (kg.)	Dose of epinephrine (mg.)	Dose of perphenazine (mg.)	Onset of arrhythmia after injection (secs.)	Duration of arrhythmia (secs.)
1	15.0	0.30	0	6	VF–Death
2	7.1	0.14	0	3	68
3	8.3	0.16	2.0	Tachycardia only	
4	8.0	0.16	2.0	10	32
5	15.0	0.30	0	2	VF–Death
6	6.3	0.12	0	4	VF–Death
2	7.1	0.14	1.8	Tachycardia only	
7	8.2	0.16	2.0	7	63
8	8.4	0.16	0	4	VF–Death
9	8.0	0.16	0	3	46
10	6.3	0.12	1.5	5	27
11	5.5	0.11	1.4	4	57
9	8.0	0.16	2.0	7	21
12	5.5	0.11	0	5	VF–Death
10	6.3	0.12	0	2	112

TABLE II

EFFECT OF PERPHENAZINE ON EPINEPHRINE-INDUCED CARDIAC ARRHYTHMIAS DURING 1.0 PER CENT FLUOTHANE-ETHER AZEOTROPE + N_2O:O_2(5:2) ANAESTHESIA IN DOGS

Dog	Weight (kg.)	Dose of epinephrine (mg.)	Dose of perphenazine (mg.)	Onset of arrhythmia after injection (secs.)	Duration of arrhythmia (secs.)
1	8.2	0.16	0	11	87
2	9.5	0.19	0	12	103
3	7.0	0.14	0	7	49
4	5.5	0.11	0	7	58
5	7.0	0.14	0	5	136
6	6.1	0.12	0	6	90
7	8.0	0.16	0	5	88
8	8.1	0.16	2.0	8	VF–Death*
1	8.2	0.16	2.0	25	46
2	9.5	0.19	2.3	17	31
3	7.0	0.14	1.8	9	5
4	5.4	0.11	1.4	23	41
5	7.0	0.14	1.8	17	60
6	6.1	0.12	1.5	14	36
7	8.0	0.16	2.0	18	42

*Severe hypoxia during anaesthesia.

recordings were taken continuously from a time just before injection of l'epinephrine was begun until either a normal sinus rhythm reappeared on the ECG, or until fatal ventricular fibrillation was obvious. In three experiments with Fluothane, electrical defibrillation and manual cardiac systole through a thoracotomy was attempted for resuscitation.

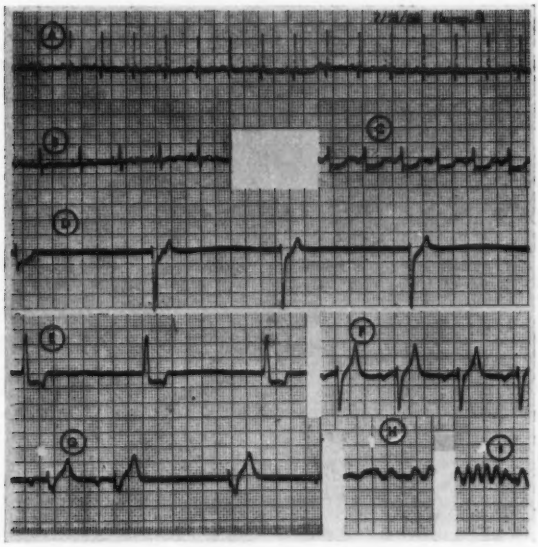

FIGURE 1. Observe that ventricular fibrillation developed when 0.3 mg. epinephrine was injected in 15 sec. after 25 min. of anaesthesia with 0.5 per cent Fluothane. A: 10:15 A.M., 15 min. after induction of anaesthesia with 150 mg. thiopental, 20 mg. succinylcholine and N_2O:O_2 (5:2), respiration controlled; B: 10:39 A.M., 24 min. anaesthesia with 0.5 per cent Fluothane + N_2O:O_2 (5:2); C: 10:40 A.M., 7 sec. after injection of epinephrine—pacemaker displaced; D: 10:41 A.M. Ventricular pacemaker; E: 10:42 A.M. Bundle branch block, supraventricular conduction; F: 10:44 A.M., intraventricular conduction defect; G: 10:45 A.M., intraventricular conduction defect; H: 10:47 A.M., ventricular fibrillation; I: 10:50 A.M., ventricular fibrillation.

RESULTS

The onset and duration of arrhythmias with Fluothane and the azeotropic mixture of Fluothane and diethyl ether are tabulated in Tables I and II. Example of the responses with and without perphenazine are shown in Figures 1, 2, 3, and 4.

Injection of perphenazine did not cause any evident change in the electrocardiographic tracing or in the blood pressure. Injection of epinephrine caused a sharp rise in blood pressure which fell rapidly within a few minutes in the surviving animals, and fell precipitously in the animals who developed ventricular fibrillation. The blood pressure response was not inverted as is seen with chlorpromazine (2).

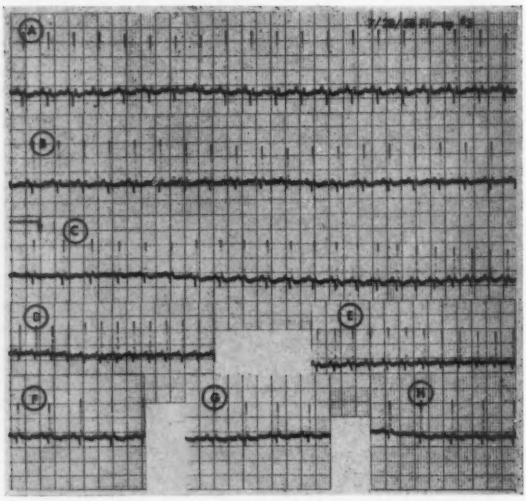

FIGURE 2. Observe that injection of epinephrine caused only a brief period of sinus tachycardia after perphenazine premedication and 23 min. of anaesthesia with 0.5 per cent Fluothane. A: 10:45 A.M., 5 min. after induction of anaesthesia, and before injection of perphenazine; B: 10:48 A.M., 2 min. after injection of 2.0 mg. perphenazine intravenously; 10:49 A.M., Fluothane 0.5 per cent added from calibrated Fluotec vaporizer; C: 11:12 A.M., showing end of injection of 8 ml. (0.16 mg.) l'epinephrine and development of sinus tachycardia; D: 11·18 A.M., sinus tachycardia; E: 11:27 A.M., sinus tachycardia; F, G, H: 11:28, 11:29, 11:30 A.M., normal rhythm. Respirator and anaesthesia discontinued 11:30 A.M., dog raised head, 11:36 A.M.

Of the eight dogs given 0.5 per cent Fluothane, five developed ventricular fibrillation (see Fig. 1). In only one of three of these were resuscitative measures of help for a short time. Two of the three surviving dogs had a variety of auricular and ventricular conduction disturbances including auriculo-ventricular nodal and ventricular extrasystoles, auriculo-ventricular block, and a very slow ventricular rhythm. These arrhythmias were indicative of a near lethal effect of epinephrine, as is seen with chloroform and cyclopropane (6). The three survivors were subsequently given perphenazine premedication and Fluothane anaesthesia, and had

no serious arrhythmias with epinephrine (see Fig. 2). None of the seven dogs that received perphenazine premedication before 0.5 per cent Fluothane anaesthesia developed ventricular fibrillation or died.

Serious ventricular arrhythmias were observed after epinephrine in the seven dogs under anaesthesia with 1 per cent Fluothane-ether azeotrope (Fig. 3).

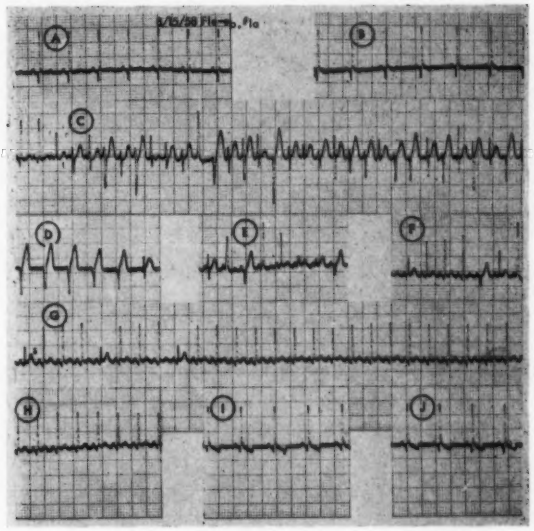

FIGURE 3. Observe multifocal ventricular extrasystoles after 0.16 mg. l'epinephrine and following 25 min. of anaesthesia with 1 per cent Fluothane-ether azeotrope. A: 2:40 P.M., 8 min. after induction of anaesthesia; 2:45 P.M., Fluothane-ether azeotrope 1 per cent added; B: 3:09 P.M., anaesthesia for 24 min., observe slightly reduced heart rate; C: 3:10 P.M., note onset of multifocal ventricular extrasystoles eleven seconds after injection of epinephrine; D: C + 30 sec., nodal rhythm; E: C + 60 sec., nodal escape; F: C + 85 sec., nodal escape; G: 3:16 P.M.. sinus tachycardia; H: 3:21 P.M., sinus tachycardia; I: 3:29 P.M., normal rhythm; J: 3:32 P.M., normal rhythm. Respirator and anaesthesia discontinued, 3:30 P.M.; Dog raised head, 3:34 P.M.

Three dogs developed a brief run of ventricular flutter and fibrillation on the electrocardiograph tracing, but each animal survived the experiment. (In a previous report (7), nine of eleven dogs survived in similar experiments). In the dogs that were given perphenazine premedication, the onset of the arrhythmias was slower and they were of shorter duration (Fig. 4). One dog in the latter group had an episode of severe hypoxia during anaesthesia when the oxygen tank ran out, and in spite of the previous administration of perphenazine, it developed ventricular fibrillation after epinephrine.

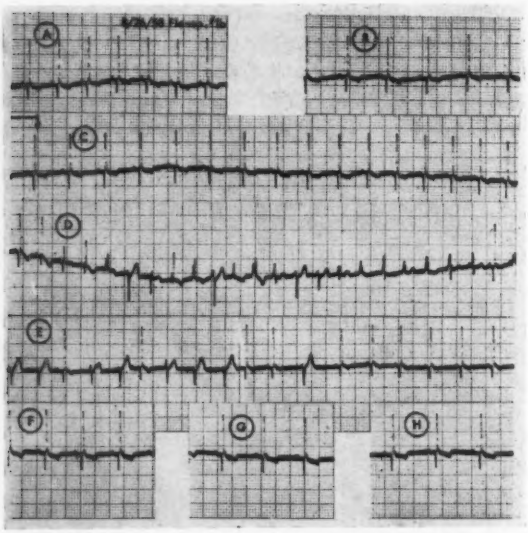

FIGURE 4. Observe short period of multifocal beats and nodal escape after perphenazine premedication and 25 min. of anaesthesia with 1 per cent Fluothane-ether azeotrope. A: 10:55 a.m., 7 min. after perphenazine and induction of anaesthesia; B: 11:20 A.M., anaesthesia for 24 min., heart rate slowed; C, D, E: 11:21 A.M., after end of injection of epinephrine, note arrhythmia beginning 25 sec. after end of injection of epinephrine which lasted 46 sec.; F, G, H: 11:31, 11:35, 11:40 A.M., normal sinus rhythm. Respirator and anaesthesia discontinued, 11:40 A.M.; dog raised head, 11:43 A.M.

DISCUSSION

The causes of cardiac arrhythmias during clinical anaesthesia are undoubtedly secondary to hypoxia and hypercarbia. This assertion applies whether the asphyxia is induced primarily by the anaesthetist, by the action of the anaesthetic drugs on the vital organs—principally, the contractile and conductive tissue of the heart—or, not infrequently by the administration of supportive drugs, especially the vasopressor catecholamines.

Perphenazine (Trilafon®) has a tranquillizing effect which is more effective than the neurosedative type of drugs, has no marked hypnotic effect, and is not as potent as the powerful psychosedatives. Its anti-emetic properties appear to be highly predictable in about one-fifth to one-tenth the dosage used with chlorpromazine. Although the dose tested in these experiments was not large for dogs, perphenazine had a very effective anti-arrhythmic action without causing inversion of the blood pressure response to l'epinephrine.

Pulmonary ventilation was controlled mechanically in these experiments because it was observed both in other experiments and during clinical anaesthesia that nodal rhythm, ventricular extrasystoles, and ventricular tachycardia were far more likely to develop during spontaneous breathing (with the associated respiratory acidosis) than when pulmonary ventilation was provided adequately by manually or mechanically augmenting the respiration (7, 8). It was found also that during spontaneous respiration it was not possible to maintain a surgical depth of anaesthesia with the lower concentration settings on the Fluotec vaporizer. Mechanical control of respiration, therefore, assured that a stable blood level of the anaesthetic vapours was readily established, and that the effects of asphyxia could not be a factor in this study.

Although Fluothane and the Fluothane-ether azeotrope may have a specific effect on myocardial conductivity and excitability which can increase the incidence of cardiac arrhythmias, these agents have many very desirable qualities. They should be administered, therefore, with the respect and caution they deserve, rather than with fearful trepidation. When serious arrhythmias exist preoperatively, it is perhaps helpful to administer an agent such as perphenazine, which will prevent the aggravation of such cardiac disturbances, and then proceed to administer these agents while making sure the pulmonary ventilation is adequate at all times. In this way, arrhythmias will be avoided, or if they do occur, will be of a mild nature with no great clinical import.

During these experiments fatal ventricular fibrillation was provoked by epinephrine very readily with 0.5 per cent Fluothane, but not with the 1 per cent Fluothane-ether azeotrope. These experiments confirm, perhaps, the clinical observation that spontaneous arrhythmias are far less frequent with the azeotrope (7). Premedication with perphenazine provided protection with both agents as long as respiratory depression or hypoxia was not permitted to occur.

Summary

Thirty acute standard experiments were carried out on twenty dogs during anaesthesia with 0.5 per cent Fluothane and 1 per cent Fluothane-ether azeotrope with N_2O:O_2 (5:2) to determine whether perphenazine would prevent serious or fatal ventricular arrhythmias, provoked by a lethal dose of l'epinephrine, after approximately 25 min. of anaesthesia. Pulmonary ventilation was controlled mechanically in a non-rebreathing system during each experiment to assure that respiratory acidosis or hypoxia would not be a factor in assessing the validity of the results, to assure that the concentration set on the Fluotec vaporizer would be delivered effectively to the dog's lungs and to assure a stable blood level of the anaesthetic agents. It was found that l'epinephrine was far more likely to cause death with 0.5 per cent Fluothane than with 1 per cent Fluothane-ether azeotrope. Perphenazine was effective in preventing death with Fluothane, and in reducing the duration and severity of arrhythmias with both Fluothane and the Fluothane-ether azeotrope.

ACKNOWLEDGMENTS

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RÉSUMÉ

Nous avons fait trente expériences chez vingt chiens soumis à l'anesthésie avec 0.5% et 1% de Fluothane-éther azéotrope et $N_2O:O_2$ (5:2) pour rechercher si la perphenazine pourrait prévenir les arythmies ventriculaires sérieuses ou fatales apparaissant à la suite de l'administration d'une dose mortelle d'épinéphrine après environ 25 minutes d'anesthésie. Au cours de chacune des expériences, nous avons contrôlé mécaniquement la ventilation pulmonaire avec un système sans réinspiration pour être assurés que l'acidose respiratoire et l'hypoxie soient exclues comme facteurs influençant les résultats et pour être assurés également que la concentration indiquée sur le vaporisateur Fluotec soit bel et bien livrée dans les poumons du chien maintenant un niveau sanguin stable d'agents anesthésiques. Nous avons observé que l'épinéphrine était aussi capable de causer la mort avec 0.5% de Fluothane qu'avec 1% de Fluothane-éther azéotrope. La perphenazine a réussi à prévenir la mort avec le Fluothane et à réduire la durée et la sévérité des arythmies aussi bien avec le Fluothane qu'avec le mélange Fluothane-éther azéotrope.

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THE EFFECT OF PERPHENAZINE ON EPINEPHRINE-INDUCED CARDIAC ARRHYTHMIAS IN DOGS: II, ANAESTHESIA WITH CYCLOPROPANE, CHLOROFORM, AND TRICHLORETHYLENE[1]

ALLEN B. DOBKIN, M.D.,[2] HARRY DONALDSON, M.D.,[2] and NOEL PURKIN, B.A.[3]

IN ADDITION to the clinical efficacy of perphenazine (Trilafon®) in alleviating symptoms of anxiety and other manifestations of emotional stress (1–4), this drug exerts a significant depressive effect on epinephrine-provoked myocardial irritability if it is administered before general anaesthesia with Fluothane and the azeotropic mixture of Fluothane and diethyl ether in dogs (5).

A dose level of perphenazine (0.25 mg./kg.) was selected for studying the effect on myocardial irritability that would not alter the pulse rate, blood pressure, or respiratory pattern in the dogs, and, if translated into the dose that would be required for clinical anaesthesia, would not be excessive in man, or exceed the effective therapeutic range for moderate sedation (0.1 mg./kg.).

Further studies in dogs were carried out to determine whether the protection afforded by perphenazine against l'epinephrine-provoked cardiac arrhythmias would apply also to anaesthesia with cyclopropane (25 per cent), chloroform (0.5 per cent), and trichlorethylene (1 per cent), since these agents are known to provoke spontaneous cardiac arrhythmias when inhaled during spontaneous respiration, and cause serious ventricular arrhythmias if l'epinphrine is administered during anaesthesia with these hydrocarbons (6, 7, 8, 9).

METHOD

Thirty-six acute experiments carried out on twenty-nine mongrel dogs are reported. These animals varied in weight from 5.5 to 17 kg. (mean, 8.5 kg.). The same technical procedure was followed as was reported in the preceding experiments (5).

The concentration of each anaesthetic agent employed was specially selected, after preliminary trials, in order to produce a stable plane of surgical anaesthesia within a few minutes when the dog's tidal volume and airway pressure were preset on a respirator, and would not cause significant cardiovascular depression or the development of electrocardiographic evidence of spontaneous myocardial irritability while pulmonary ventilation was adequate.

Cyclopropane-oxygen (25–75 per cent) was administered through a semi-closed circle system with fresh baralyme in the circuit, employing gas flows of at least 200 ml. cyclopropane and 600 ml. oxygen. Chloroform 0.5 per cent and trichlorethylene 1 per cent were administered from a calibrated Fluotec vaporizer with

[1]Supported in part by a grant-in-aid from Schering Corporation, Montreal, Canada.

[2]From the Department of Anaesthesia, University of Saskatchewan College of Medicine and the Anaesthesia Laboratory, Medical Research Building, Saskatoon, Canada.

[3]Medical Student Research Assistant from the University of Saskatchewan College of Medicine.

the vaporization setting at 0.5 and 3 per cent respectively (10). At least 7 L. gas/min. flowed through the vaporizer continuously (N_2O, 5, L. + O_2, 2 L.). The concentration, dose and rate of injection of epinephrine (0.02 mg./ml./kg. body weight/sec.) was the same as used previously (5), and was also specially selected in order that the electrocardiogram of the dog would probably show ventricular extrasystoles, ventricular tachycardia, multifocal ventricular extrasystoles, or ventricular fibrillation after 20 min. of each of the anaesthetic agents.

Results

Cyclopropane 25 per cent and Oxygen 75 per cent

No significant spontaneous arrhythmias appeared during the 20 minutes of anaesthesia in twelve acute experiments on nine dogs. The only alteration that was observed on the electrocardiogram was a slight sinus arrhythmia and a progressive

TABLE I

Effect of Perphenazine on Epinephrine-induced Cardiac Arrhythmias during 25 per cent Cyclopropane-75 per cent O_2 Anaesthesia in Dogs

Dog	Weight (kg.)	Dose of epinephrine (mg.)	Dose of perphenazine (mg.)	Onset of arrhythmia after injection (secs.)	Duration of arrhythmia (secs.)
1	11.0	0.22	2.8	10	7 (Fig. 1)
2	6.2	0.12	1.5	3	24
3	7.8	0.16	0	− 2	530–VF
4	9.0	0.18	0	− 4	194–VF
5	8.0	0.16	2.0	− 1	6
6	6.0	0.12	1.5	11	13
1	11.0	0.22	0	− 3	224–VF
3	7.8	0.16	2.0	8	9
4	9.0	0.18	2.3	Tachycardia–Bradycardia	
7	16.0	0.32	4.0	VF–Death*	
8	17.0	0.34	4.2	12	36 (Fig. 2)
9	13.2	0.26	3.3	0	0†

*Mechanical difficulty during anaesthesia.
†Bradycardia and hypotension after experiment, death in 3 hrs.

slowing of the heart rate. In seven of the nine dogs, the heart rate slowed to less than half after 20 minutes of cyclopropane, as compared to that in the control period (Fig. 1A, B). In the other two dogs there was little or no change in the heart rate (Fig. 2A and B). In six experiments, femoral artery pressures were recorded, but there was no significant alteration before the injection of l'epinephrine.

In the three animals which did not receive perphenazine there was a period of at least 3 minutes in which paroxysmal auricular tachycardia, ventricular tachycardia, multifocal ventricular extrasystoles, and ventricular fibrillation appeared on the electrocardiogram after the injection of l'epinephrine. The blood pressure rose immediately after injection of l'epinephrine and then fell rapidly to a very low level.

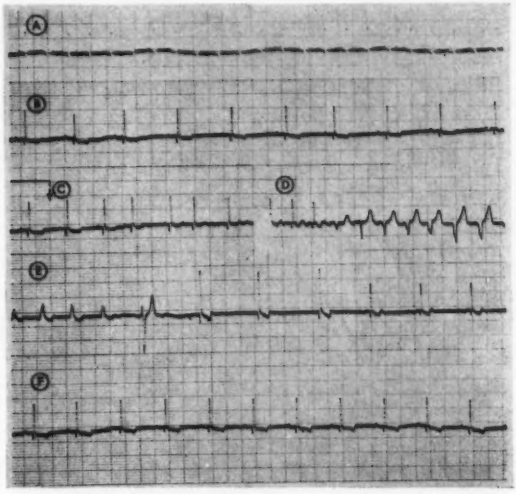

FIGURE 1. Observe bradycardia after 20 min. of 25 per cent cyclopropane, and short run of paroxysmal ventricular tachycardia after 0.22 mg. l'epinephrine in 11 kg. dog premedicated with 2.8 mg. perphenazine. A, control before cyclopropane, slight sinus arrhythmia at 188/min.; B, after 20 min. of 25 per cent cyclopropane, slight sinus arrhythmia at 82/min.; C, end of injection of l'epinephrine, rate increasing; D, 9 sec. after C, paroxysmal ventricular tachycardia at 180/min.; E, 14 sec. after C, P waves reappear; F, 30 sec. after C, slight sinus arrhythmia at 100/min.

In the other nine experiments in which perphenazine premedication was administered, the following observations were recorded. One dog (no. 4) had a brief period of paroxysmal auricular tachycardia, followed by a short run of slow ventricular rhythm, then normal complexes appeared at the rate seen before the injection of epinephrine. In another experiment (no. 7) there was some mechanical difficulty with the automatic respirator which was ventilating the dog. This caused signs of obstructive breathing intermittently during the 20 minutes control period. When the l'epinephrine was injected, ventricular tachycardia developed immediately and changed abruptly in a few seconds to ventricular fibrillation. Another dog (no. 9) had no arrhythmias during the experiment, but developed a severe bradycardia and hypotension about 7 minutes after the l'epinephrine injection and discontinuation of cyclopropane. This rate was regular at between 26–30/minutes for over 2½ hrs., with gradual reduction of the voltage. During this time only oxygen was administered with the respirator. Spontaneous breathing did not return and the blood pressure became too low to record after 3 hrs. When the respirator was disconnected the animal expired promptly. This death may have been due to "cyclopropane shock" or to the effects of a relative

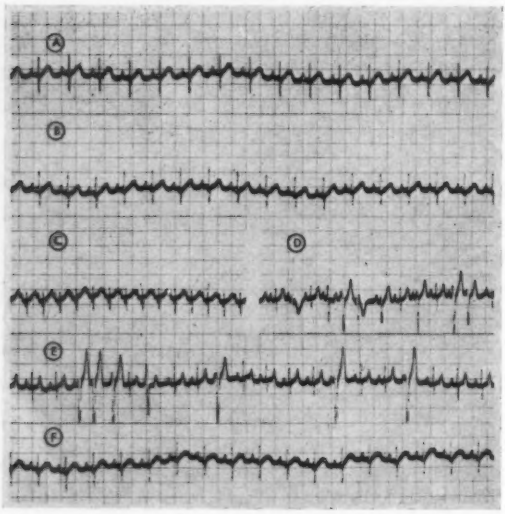

FIGURE 2. Observe that there was no alteration in the heart rate after 20 min. of 25 per cent cyclopropane, and short run of ventricular extrasystoles after 0.34 mg. l'epinephrine. A, control before cyclopropane (after perphenazine), slight sinus arrhythmia at 144/min.; B, after 20 min. of 25 per cent cyclopropane, unchanged; C, end of injection of l'epinephrine, heart rate increased to 230/min.; D, 12 sec. after C, multifocal ventricular extrasystoles; E, 30 sec. after C, ventricular extrasystoles, followed by normal rhythm; F, 60 sec. after C, normal rhythm; rate 150/min.

overdose of cyclopropane. A response like this was reported by Morris and associates in a similar experiment with chloroform (9).

The other six dogs that received perphenazine had very brief runs of paroxysmal supraventricular tachycardia with a few ventricular extrasystoles (see Figs. 1 and 2, C to F).

Chloroform 0.5 per cent with Nitrous Oxide 70 per cent and Oxygen 30 per cent

These experiments were done initially with 1 per cent chloroform, because it was reported that dogs were very much more resistant to chloroform-epinephrine syncope than to that with cyclopropane (6). However, this concentration caused hypotension. By trial it was found subsequently that 0.5 per cent chloroform and 70 per cent nitrous oxide with controlled respiration was sufficient to produce a preparation that would respond to epinephrine with ventricular arrhythmias, but would not cause marked alteration of the blood pressure during the preliminary 20 minutes of anaesthesia.

TABLE II

EFFECT OF PERPHENAZINE ON EPINEPHRINE-INDUCED CARDIAC ARRHYTHMIAS DURING 0.5 PER CENT CHLOROFORM + N_2O:O_2(5:2) ANAESTHESIA IN DOGS

Dog	Weight (kg.)	Dose of epinephrine (mg.)	Dose of perphenazine (mg.)	Onset of arrhythmia after injection (secs.)	Duration of arrhythmia (secs.)
1	11.0	0.22	2.8	3	74 (see Fig. 3)
2	9.0	0.18	2.3	9	56
3	6.9	0.14	0	4	144
4	5.9	0.12	0	3	93
5	9.1	0.18	2.3	Tachycardia only	
6	5.0	0.10	1.3	5	16
1	11.0	0.22	0	−1	VF–Death (see Fig. 4)
7	6.0	0.12	0	0	264
8	10.4	0.21	2.5	2	46
9	9.0	0.18	2.3	3	18
10	8.0	0.16	0	2	156
5	9.1	0.18	0	−2	290

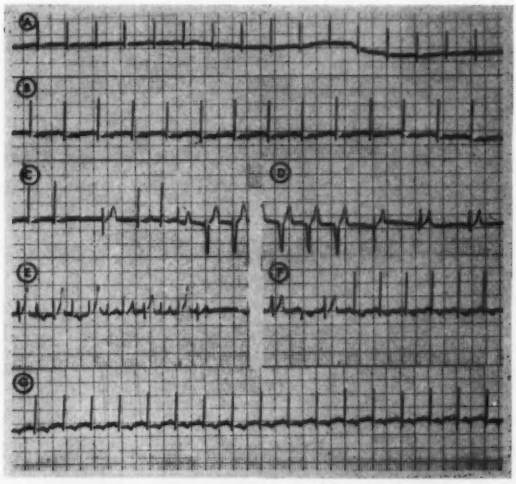

FIGURE 3. Observe slight bradycardia after 20 min. of 0.5 per cent chloroform and ventricular arrhythmias after 0.22 mg. epinephrine in 11 kg. dog premedicated with 2.8 perphenazine. A, control before chloroform, rate 136/min.; B, after 20 min. 0.5 per cent chloroform, rate 120/min.; C, end of injection of l'epinephrine, onset of A–V dissociation; D, 30 sec. after C, A–V dissociation; E, 45 sec. after C, multifocal ventricular extrasystoles; F, 73 sec. after C, normal sinus rhythm reappears; G, 90 sec. after C, normal sinus rhythm, rate 140/min.

No spontaneous cardiac arrhythmias appeared in the twelve acute experiments in the ten dogs, either during induction of anaesthesia or during the 20 minutes prior to administration of l'epinephrine. Each of the dogs had a slight reduction in the heart rate within about 5 minutes after beginning the chloroform. The reduction of heart rate was not progressive during the 20 minutes of anaesthesia (see Figs. 3 A–B, and 4 A–B).

In the six experiments in which the animal received perphenazine, a brief run of increased heart rate, followed by atrioventricular rhythm, nodal and ventricular extrasystoles and slow ventricular rhythm were observed. In only one of these animals did the arrhythmias persist for more than 1 minute (see Fig. 3).

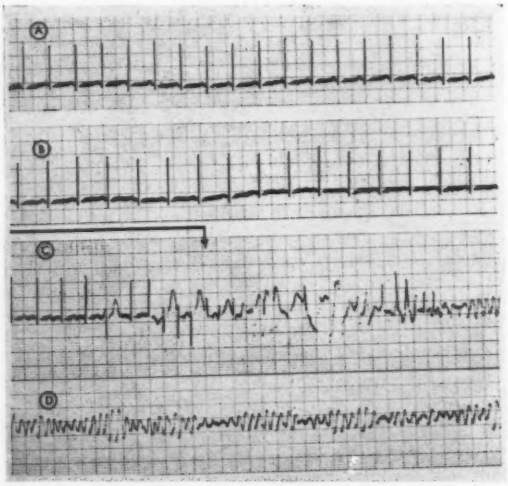

FIGURE 4. Observe slight bradycardia after 20 min. of 0.5 per cent chloroform and telescoping of progression of arrhythmias to ventricular fibrillation when epinephrine (0.22 mg.) was administered in the unpremedicated dog (same animal as in Fig. 3).

In the other six experiments, in which no perphenazine was given, the animals developed bursts of supraventricular tachycardia, ventricular tachycardia, and multifocal ventricular extrasystoles. In five of these experiments the arrhythmias persisted for at least 90 seconds and showed the appearance of a "prefibrillation phase." One animal abruptly developed ventricular fibrillation 4 seconds after the injection of l'epinephrine (see Fig. 4).

Trichlorethylene 1 per cent with Nitrous Oxide 70 per cent and Oxygen 30 per cent

No significant spontaneous arrhythmias appeared during the 20 minutes of anaesthesia in twelve acute experiments on ten dogs. There was also no significant alteration in the heart rate or blood pressure. In the six experiments in which

TABLE III

EFFECT OF PERPHENAZINE ON EPINEPHRINE-INDUCED CARDIAC ARRHYTHMIAS DURING 1 PER CENT TRICHLORETHYLENE + N_2O:O_2(5:2) ANAESTHESIA IN DOGS

Dog	Weight (kg.)	Dose of epinephrine (mg.)	Dose of perphenazine (mg.)	Onset of arrhythmia after injection (secs.)	Duration of arrhythmia (secs.)
1	8.6	0.17	2.2	6	18
2	7.0	0.14	1.8	7	27
3	6.0	0.12	0	3	163
4	5.5	0.11	0	7	221
5	8.3	0.16	2.0	Tachycardia only	
6	6.8	0.14	1.8	14	55
7	8.0	0.16	0	4	VT & VF–13 min. (intermittently)
2	7.0	0.14	0	3	VF–Death
8	6.4	0.13	1.6	5	66
9	11.2	0.22	2.8	8	124 (Fig. 5)
5	8.3	0.16	0	6	VF–Death
10	8.2	0.16	0	3	182 (Fig. 6)

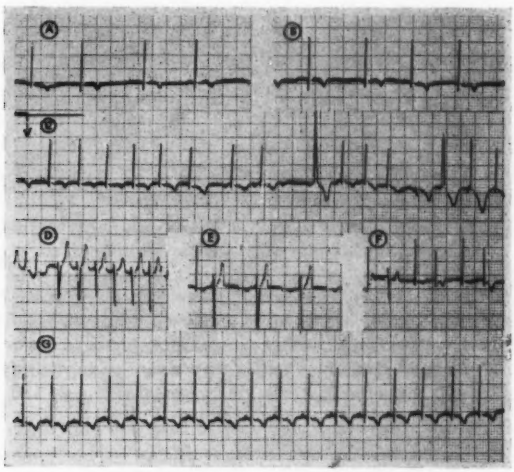

FIGURE 5. Observe ventricular arrhythmias after l'epinephrine. A, control before trichlorethylene, sinus arrhythmia @ 82; B, after 20 min. 1 per cent trichlorethylene, sinus arrhythmia @ 84; C, end of injection of l'epinephrine (0.22 mg.), immediate increase in heart rate, and appearance of ventricular extrasystoles; D, E, F: 30, 40 and 120 sec. after C, ventricular extrasystoles; G, 130 sec. after C, sinus rhythm.

perphenazine premedication was given, there were no arrhythmias in one, and up to 2 minutes of intermittent ventricular arrhythmias in the other five after the injection of epinephrine (see Fig. 5).

In the other six experiments, the animals did not receive perphenazine. Three of them developed ventricular fibrillation—two of these died quickly, while the other alternated between ventricular tachycardia, multifocal ventricular extrasystoles, and ventricular fibrillation for 13 minutes. The other three had long runs of ventricular arrhythmias that appeared at times to change to fibrillation, but they each reverted to a slow ventricular rhythm, which gradually accelerated until a near normal rate and configuration reappeared (see Fig. 6).

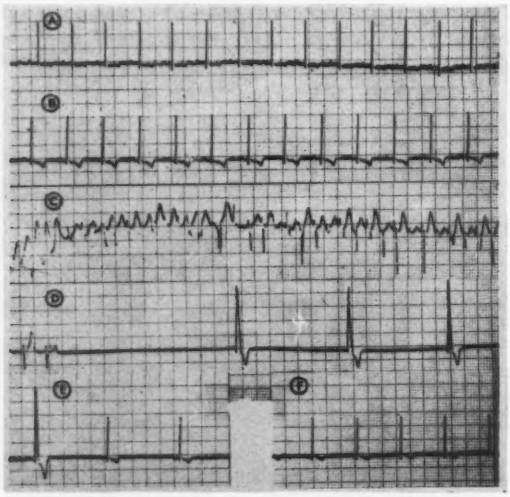

FIGURE 6. Observe "prefibrillation phase" of ventricular arrhythmias appearing shortly after injection of epinephrine. A, control before trichlorethylene, rate 115/min.; B, after 20 min. 1 per cent trichlorethylene, rate 108/min.; C, 3 sec. after injection of l'epinephrine (0.16 mg.)—brief appearance of ventricular fibrillation, then multifocal ventricular extrasystoles; D, 166 sec. after C, slow ventricular rhythm; E, 180 sec. after C, return of sinus rhythm; F, 240 sec. after C, sinus rhythm, rate 90/min.

DISCUSSION

The demonstration of a protective action against experimentally provoked cardiac arrhythmias by epinephrine has been carried out with many drugs, employing a variety of techniques (11). These have led to wide variations in experimental observations and in opinions expressed regarding the conclusions that may be drawn.

The procedure employed in the present study was selected in order to eliminate as many variable factors as possible. A small amount of thiopental was given intravenously in order to prepare the animal quickly, and to avoid a stormy induction of anaesthesia. Respiratory tidal volume and airway pressure

were regulated in order to assure that pulmonary ventilation would be adequate at all times, and that the desired concentration of the primary anaesthetic would be delivered to the lungs and would establish a surgical plane of anaesthesia in a few minutes. The liquid anaesthetics were delivered from a calibrated Fluotec vaporizer, which is temperature compensated, in order that variation in the concentration of these agents would be avoided even if the animal should take a deep breath, and to eliminate the possibility of sudden wide changes in the depth of anaesthesia. The specific concentrations of the anaesthetics which were selected were chosen because they did not cause marked hypotension (or hypertension) during the initial 20 minutes of anaesthesia which were required to prepare the animal for the acute experiment.

A fixed concentration and rate of injection were decided upon for the intravenous administration of l'epinephrine, with total dose dependent upon body weight. This method was used rather than administering l'epinephrine until a particular cardiac response might be observed because the latter technique eliminates the factors of rate and dose and renders comparison of response with different anaesthetic agents more difficult.

A light level of chloroform anaesthesia was chosen because deep chloroform anaesthesia depresses all functions of the heart, lowers the blood pressure, and perhaps reduces the susceptibility to the peculiarly lethal effect of l'epinephrine. In fact, under deep chloroform, l'epinephrine may be an effective restorative of a rapidly succumbing circulation (12, 13). This is probably true also with Fluothane and the azeotropic mixture of Fluothane and diethyl ether (5). On the other hand, with artificial respiration, a high concentration of cyclopropane was used because this abolishes or minimizes the incidence of spontaneous arrhythmias, but also increases the susceptibility to ventricular arrhythmias provoked by l'epinephrine (14).

It was stated that, clinically, spontaneous cardiac arrhythmias have been noticed frequently during trichlorethylene anaesthesia either by palpation of the pulse or by the electrocardiograph (7, 8). In these early reports, the concentration of the inhaled vapour probably exceeded 2 per cent, or the arrhythmias were transient and appeared only during induction of anaesthesia (15). Serious ventricular arrhythmias may occur spontaneously only under deep anaesthesia with trichlorethylene, when rapid shallow breathing occurs, and causes hypoxaemia (16). In the animal studies reported here, no spontaneous arrhythmias were observed during the initial 20 minutes of anaesthesia in distinction to what has been observed by others (8, 9). This may be explained by the fact that induction of anaesthesia was always smooth, and pulmonary ventilation was supported sufficiently to maintain normal respiration. When l'epinephrine was injected, however, these animals appeared to be far more susceptible to ventricular fibrillation than with any of the other agents studied.

Perphenazine was observed to exert a protective action on the heart against ventricular arrhythmias, without apparent potentiation of the effect of the primary anaesthetics, and without altering the pulse rate or the blood pressure of the dogs, although the arrhythmias were not eliminated.

The complete elimination of cardiac arrhythmias with perphenazine may be possible by greatly increasing the dose or by altering the amount of anaesthetics administered. However, the first manoeuvre would cause potentiation of the anaesthetics, and induce undesirable lowering of the blood pressure and possibly myocardial depression, while the second manoeuvre would alter grossly the optimum experimental procedure, and detract from the validity of any conclusions that may be drawn from the observations.

It appeared from these studies that perphenazine was more potent than chlorpromazine in reducing the duration and severity of cardiac arrhythmias provoked by l'epinephrine, and had no significant effect on the pressor response to l'epinephrine at the dose level tested (17, 18, 19).

Summary and Conclusions

The effect of 25 per cent cyclopropane, 0.5 per cent chloroform with 70 per cent nitrous oxide and 1 per cent trichlorethylene with 70 per cent nitrous oxide on the heart rate was observed during thirty-six acute experiments in dogs in which pulmonary ventilation was regulated, and the concentrations of the inhaled anaesthetics were accurately controlled. There was marked slowing of the heart rate with cyclopropane, slight slowing with chloroform, and little or no change with trichlorethylene. There was no significant difference in the heart rate in the animals that were premedicated with perphenazine 0.25 mg./kg., as compared to the unpremedicated animals.

Sensitization to epinephrine-provoked cardiac arrhythmias by a standard concentration and rate of injection (0.02 mg./ml./sec.) were observed, when the total dose was regulated according to the animals' weight. It was found that ventricular fibrillation was less likely to occur when epinephrine was injected during anaesthesia with 0.5 per cent chloroform than with 25 per cent cyclopropane, or with 1 per cent trichlorethylene. In a similar study with Fluothane and the azeotropic mixture of Fluothane and diethyl ether, the cardiac response to epinephrine with 0.5 per cent Fluothane was similar to that with 25 per cent cyclopropane, and the 1 per cent of the azeotropic mixture was similar to that with 0.5 per cent chloroform.

Premedication with perphenazine (0.25 mg./kg.) caused a significant reduction in the severity and duration of the cardiac arrhythmias provoked by epinephrine if pulmonary ventilation was adequate throughout the experiment, but did not cause reversal of the pressor response. It was suggested that the elimination of epinephrine-provoked cardiac arrhythmias by perphenazine would require such alteration in the depth of anaesthesia or dose of perphenazine as would reduce the validity of the results of these experiments for practical application.

Acknowledgments

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RÉSUMÉ

Nous avons étudié l'effet sur le rythme cardiaque de 25 pour cent de cyclopropane, de 0.5 pour cent de chloroforme avec 70 pour cent de protoxide d'azote et de 1 pour cent de trichlorethylène avec 70 pour cent de protoxide d'azote chez trente-six chiens dont la ventilation pulmonaire était maintenue et dont les concentrations d'agents anesthésiques inhalés étaient précisement contrôlées. Nous avons observé un ralentissement marqué du cœur avec le cyclopropane, un léger ralentissement avec le chloroforme et peu ou pas de changement avec le trichlorethylène. Chez les animaux prémédiqués avec de la perphénazine 0.25 mg./kg., nous n'avons pas observé de différence dans le rythme cardiaque comparativement aux animaux non prémédiqués.

Nous avons observé une sensibilisation à provoquer des arythmies cardiaques par l'épinéphrine à une concentration et à une vitesse d'injection standard (0.02 mg./ml. sec.) lorsque la dose totale était calculée d'après le poids des animaux. Nous avons observé que la fibrillation ventriculaire était moins exposée à survenir lorsque l'épinéphrine était injectée durant l'anesthésie avec 0.5 pour cent de chloroforme que durant l'anesthésie avec 25 pour cent de cyclopropane ou avec 1 pour cent de trichlorethylène. A la suite d'une étude semblable avec le Fluothane et le mélange azéotrope Fluothane et éther diéthylique, nous avons noté que la réponse cardiaque à l'épinéphrine avec 0.5 pour cent de Fluothane était semblable à celle observée avec 25 pour cent de cyclopropane et que celle de 1 pour cent du mélange azéotrope était semblable à celle de 0.5 pour cent de chloroforme.

La prémédication avec de la perphénazine (0.25 mg./kg.) a entraîné une réduction importante de la sévérité et de la durée des arythmies cardiaques provoquées par l'épinéphrine à la condition que la ventilation pulmonaire soit adéquate durant toute l'expérience, mais elle n'a pas inversé l'effet presseur. Il nous a semblé que l'élimination par la perphénazine des arythmies ventriculaires provoquées par l'épinéphrine nécessiterait une telle profondeur d'anesthésie ou des doses telles de perphénazine que la valeur pratique des résultats de ces expériences serait bien diminuée.

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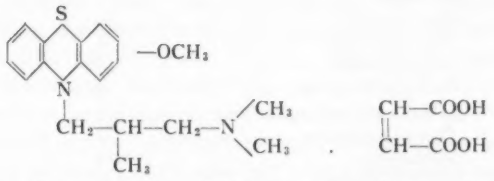
A CLINICAL EVALUATION OF LEVOMEPROMAZINE IN ANAESTHESIA[1]

A. ROMAGNOLI, M.D., M. COHEN, M.D., and M. J. DIAMOND, M.B., CH.B.[2]

SIGWALD AND CO-WORKERS (1) reported in 1956 on a new phenothiazine derivative prepared by the Rhône-Poulenc Research Laboratories: R.P. 7044 or levomepromazine, 1-methoxy-3-(dimethylamino-3′-methyl-2′-propyl)-10-phenothiazine acid maleate.[3]



It is a white powder, sparingly soluble in water and ethanol; its molecular weight is 444.5. The pH of a saturated aqueous solution is between 3.0 and 5.0. The acute toxicity was found similar to that of chlorpromazine (2). Experiments on chronic toxicity demonstrated that a dose of 10 mg./kg./day caused no histological changes in the rat. In the dog 5 mg./kg. daily brought about hypomyotonia and hypotension, splenic haematopoietic block, and hepatic parenchymal congestion: all these changes were slowly reversible. R.P. 7044 was demonstrated to be adrenolytic, sympatholytic, and weakly parasympatholytic. It is a very potent antihistaminic, anti-emetic, antishock, spasmolytic, and has a depressive psychomotor effect 75 per cent greater than chlorpromazine. Finally levomepromazine potentiates narcosis considerably, but its potentiating action on analgesia is not as great. Courvoisier *et al.* (3) extended the experimental studies on R.P. 7044 and fundamentally confirmed the previous results. Faure *et al.* (4) used it successfully on children under the age of thirteen years, while other authors (5, 6, 7) tried it on patients of all ages in good as well as poor general condition affected by a large variety of psychiatric and neurological disorders. Never did they encounter dangerous reactions; on the contrary, their results in this field of medicine were most encouraging.

In view of the qualities manifested by levomepromazine, we decided to use this drug in a trial series of anaesthetics for surgical operations. The patients were not selected, but strong young male adults were avoided in our series, because neuroplegic drugs act poorly on this type of subject. The drug was only administered intravenously in the operating room to produce or to supplement anaesthesia. None of our patients was ambulatory. Children were also excluded from our series merely because of the technical difficulty involved in convincing our young patients to willingly undergo an intravenous injection. We

[1]Supported by Poulenc Limited, Montreal.

[2]Department of Anesthesia, Jewish General Hospital, Montreal.

[3]Trade name, Nozinan, Poulenc Limited.

varied the initial dose of the drug under study according to the condition of the patient, the type of operation, and the operator. The final result was gauged so as to obtain the same smooth and uneventful anaesthesia, thus cancelling all other factors. A total of one hundred and fifty patients were given the drug in this series. The surgical operations during which R.P. 7044 was administered were:

Gastrectomies	6
Cholecystectomies	15
Bowel resections	19
Hysterectomies	17
Hernias	11
Mastectomies	10
Prostatectomies	22
Vaginal repairs	10
Orthopaedic operations	9
E.N.T. and neck operations	13
Plastic operations	7
Endoscopies	11
TOTAL	150

Levomepromazine was associated during its administration with several other drugs in everyday use by the anaesthetist; the results showed that there was no contraindication whatsoever to this mixing of drugs.

TABLE I

TYPES OF ANAESTHETICS WITH WHICH R.P. 7044 WAS ADMINISTERED

Group	Induction	Maintenance	
A	Thiopentone	Nitrous oxide	48
		℄ Succinylcholine	27
		℄ Curare	10
B	Thiopentone	Nitrous oxide–Fluothane	18
		℄ Succinylcholine	19
		℄ Curare	12
C	Thiopentone	Cyclopropane	4
D	Nitrous oxide	Nitrous oxide	4
E	Spinal anaesthesia		8

The patient response to curarizing agents, both of the competitive and depolarizing type was unchanged, and no difference could be noted from the response of patients to whom R.P. 7044 had not been given.

The results obtained from this series of cases were indeed most encouraging. Assessment of the results was done as follows: results were judged poor, satisfactory, or good, according to the nature of the anaesthetic induction, the maintenance, the operative condition, and the recovery, and in relation to the presence of side effects. A result was considered poor when there were complaints and unbalanced anaesthesia and when the technique had to be abandoned. In a satisfactory result the final outcome was good with the patient doing well throughout, even though the anaesthesia was slightly unsettled at times. Finally, for a good result everything went well at all times.

TABLE II

CLASSIFICATION OF RESULTS

Groups	*A*	*B*	*C*	*D*	*E*
Good	71	47	4	4	8
Satisfactory	10	2			
Poor	4				

The four poor results recorded belong to Group A (Table I), where thiopentone-nitrous oxide only were administered together with the drug under study; in these four cases, the patients reacted to painful stimuli by coughing and moving so much that the technique had to be abandoned. One of these was also complicated by hypotension. This was a 59-year-old white female patient in good general condition, undergoing a vaginal hysterectomy and anterior and posterior colporrhaphy: B.P. 140/80, pulse 75/min., Hb. 75 per cent, heart and lungs normal. The anaesthetic was never well under control and during the 150 min. that the procedure lasted the patient often reacted to pain by moving and by coughing. Only 15 mg. of levomepromazine could be given because of a steadily dropping blood pressure (70/50 mm.Hg) which responded well and permanently to Vasoxyl 10 mg. intravenously and 5 mg. intramuscularly 10 min. later. The patient had all the laryngeal and pharyngeal reflexes within 10 min. of the end of the operative procedure, while the blood pressure was stabilized at 110/70 mm.Hg. The patient made an uneventful recovery.

The time which elapsed between the return to the ward and the first administration of analgesic was carefully recorded in our series. It was compared with a similar number of cases where Levomepromazine was not given because it was noticed from the beginning that the difference was considerable and of clinical significance.

The average time free from pain for the 150 patients who received R.P. 7044 was 6 hrs. and 2 min., while the same interval of time in 150 similar patients kept as controls was 2 hrs. and 18 min. Amongst the first series there were 32 patients who did not require postoperative sedation at all, while in the second series there were only eight such patients. The difference is indeed striking and requires no further comment.

The pharmacological actions as they appeared during this series were indeed encouraging.

The dosage varied from 10 mg. to a maximum of 30 mg. intravenously, but the drug had to be diluted before administration or irritation of the vein developed. The full onset of action appeared to be slow over a period of 10 to 15 min. at least. The effect lasted several hours. During this time the patient, if under anaesthesia, appeared pale, dry, warm, with quiet even respirations. The eyes were fixed in central position; the pupils were in intense myosis. The absence of any one of the signs mentioned meant that the anaesthetic was not well balanced and that the patient might move or groan suddenly. We found that provided the pupil was in extreme myosis, all was well, but the slightest widening meant that more levomepromazine was required. The amount of added anaesthetic necessary to maintain a smooth and adequate operative condition was small, and the patient responded within minutes of the discontinuation.

Under levomepromazine the heart rate was slow within normal range. The pulse was regular and full; the blood pressure drop was around 15 per cent. Often subsequent small doses did not cause any drop.

The respiratory rate was 16 to 24 per minute, with normal depth. No untoward effects were noticed in two patients known to be mild asthmatics.

Levomepromazine in the dosage used caused a good degree of sedation, depression of reflexes, and a moderate amount of relaxation, probably of extrapyramidal origin. Under these conditions clinical potentiation of anaesthetics and analgesics was the logical consequence. When the anaesthetic was discontinued and the patient returned to the ward, the drug maintained the patient in a condition of apathy and disinterest toward the environment with a certain amount of separation from pain as shown by the delayed need for postoperative analgesia, and there was no vomiting.

The action on the vegetative system was definite, but not clear cut. The pupils were constricted, the mucosae and the skin dry and pale, the blood pressure lowered with a tendency to bradycardia.

Summary

Levomepromazine, R.P. 7044, was evaluated in a series of 150 patients undergoing anaesthesia and the pharmacological actions were examined as they appeared to the anaesthetist in the operating room. Levomepromazine was found to be a very useful drug both during anaesthesia and postoperatively, because it decreased significantly the amount of both the anaesthetic and the postoperative analgesic drug needed.

Résumé

La lévomépromazine, 7044 R.P., a été évaluée chez un groupe de 150 patients soumis à l'anesthésie et son activité pharmacodynamique a été étudiée par l'anesthésiste dans la salle d'operation. La lévomépromazine s'est avérée une drogue très utile au cours de l'anesthésie et également dans la période postopératoire, parce qu'elle permet de diminuer de façon significative les besoins en anesthésique et en analgésique post-opératoire.

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CHANGES IN THE ELECTROCARDIOGRAM DURING INDUCTION OF ANAESTHESIA AND ENDOTRACHEAL INTUBATION

MARVIN J. NOBLE and WILLIAM S. DERRICK, M.D.[1]

EARLIER STUDIES on electrocardiogram changes during induction of anaesthesia and endotracheal intubation have pointed up the possibility of a vago-vagal reflex as the source of cardiac arrhythmias. Reid and Brace (1) demonstrated cardiac acceleration resulting from stimulation of respiratory mucosa during endotracheal intubation. More recently, reduction in the number of arrhythmias and tachycardias has been accomplished by changing the anaesthetic used in order to block this reflex arc (2, 3, 4). In another study, Denson and Joseph (5) showed that adequate ventilation of the patient prior to intubation would prevent the development of cardiac arrhythmias. It has also been demonstrated that a minimal level of anaesthesia during laryngoscopy and endotracheal intubation predisposes the patient to a rise in blood pressure and tachycardia (6).

METHODS

The patients included in this study were premedicated with pentobarbital, meperidine, promethazine, and scopolamine. Anaesthesia induction consisted of sufficient thiopentone, intravenously, to put the patient to sleep, followed by nitrous oxide, ether, oxygen, hyperventilation, and finally, endotracheal intubation. In most cases, 4 to 9 mg. of d-tubocurarine were administered intravenously about 5 min. before intubation. There was one case of a ten-month old infant who was induced with cyclopropane, nitrous oxide, oxygen, and then maintained on cyclopropane, nitrous oxide, ether, and oxygen mixture without intubating. The three other exceptions to the method above were an elderly tracheostomized patient, one who received the above anaesthesia but was not intubated and one who received thiopentone, nitrous oxide ,and succinylcholine.

Except for two patients on whom lead I was used, patients were monitored via lead II using a Sanborn Model 51 Viso Cardiette direct-writing electrocardiograph. Tracings were taken before induction, at various stages of induction, during laryngoscopy and intubation, and at brief intervals shortly following intubation.

RESULTS

A total of 80 inductions were followed. Eighteen patients developed arrhythmias. Changes in the height of the P, QRS, and T waves were noted. Depression of the S–T segment, prolongation of the P–R and QRS intervals, and notching or slurring of the QRS complex were also observed. A summary of these findings and the time relationship in respect to intubation is found in Table I.

[1]The University of Texas, M. D. Anderson Hospital and Tumor Institute, Houston, Texas.

The types of arrhythmia included premature ventricular and premature auricular systoles, A–V nodal rhythm, interference dissociation, and sinus arrhythmia. Changes in the P and T waves were mainly small height changes but in a few instances, the wave disappeared. The miscellaneous changes classified in Table I as "Others" include notching and wave duration changes. There may have been more than one change in a wave during the induction, but only the first change is considered in Table I.

TABLE I

CHANGES IN THE ECG DURING INDUCTION AND INTUBATION

Change	Time with respect to intubation			Total
	Before	During	After	
Arrhythmia	11	6	1	18
P-wave height	29	3	0	32
QRS height	7	7	3	17
T-wave height	23	4	2	29
S–T depression	2	2	1	5
Others	2	6	0	8

Tachycardia was defined in a relative sense for the purpose of this study as an increase in the heart rate of at least 22 beats per minute. The period of change in rate to be observed was arbitrarily selected to begin with laryngoscopy and to end 3 minutes after intubation. In 78 intubations, there were 39 relative tachycardias produced. There were two cases of relative bradycardia.

It was noted that the ECG tracing taken in the operating room after premedication but before anaesthesia did not always correspond to that taken before premedication.

DISCUSSION

The significance of changes in depolarization and repolarization voltages in the myocardium during induction of anaesthesia is not clearly known. Lepeshkin (7) has shown that cold fluids given intravenously will affect the T wave. It is notable that most changes in the present study occurred before laryngoscopy and endotracheal intubation. Only the changes in the QRS height and the S–T depressions were equal in number before and during endotracheal intubation. There were some changes in wave height after intubation, but these were secondary changes and are therefore not listed in Table I. The time relation of these changes, especially the arrhythmias, would indicate a role being played by the premedicating drugs and/or the anaesthetics used for induction. This role has not been fully described.

The great number of relative tachycardias seen on intubation (50 per cent) is in keeping with earlier findings (1, 2, 3, 4). Here again, timing is relevant as the greatest rate occurred about 1½ to 2 minutes after intubation. This time was

usually ½ to 1 minute after the cuff on the endotracheal tube was inflated. This result indicates greater stimulation from cuff inflation than from intubation *per se*.

Conclusions and Summary

The stimulation of respiratory epithelium seemingly plays a large role in causing a relative tachycardia and, in addition, the role of the premedication drugs and the anaesthetics used is of increasing interest as the source of pre-endotracheal intubation ECG changes.

Eighty patients were followed through induction of anaesthesia and endotracheal intubation with lead II electrocardiograms. Changes in wave voltage, rate, and rhythm were observed. The heart rate increased in 50 per cent of the patients upon intubation. Approximately 60 per cent of other electrocarliogram changes occurred before laryngoscopy and endotracheal intubation.

Acknowledgment

We are indebted to Miss Joyce E. Nichols for technical assistance in electrocardiography.

Résumé

Chez 80 malades, nous avons fait un tracé électrocardiographique en deuxième dérivation au cours de l'induction de l'anesthésie et de l'intubation endotrachéale. Nous avons observé des modifications dans le voltage, la vitesse et le rythme. Les malades que nous avons étudiés avaient reçu comme prémédication: du pentobarbital, de la mépéridine, de la promethazine et de la scopolamine. Nous avons fait l'induction de l'anesthésie en donnant du thiopentone en quantité suffisante pour obtenir du sommeil et nous avons continué avec du protoxide d'azote, de l'éther, de l'oxygène, de l'hyperventilation et ensuite nous avons pratiqué l'intubation endotrachéale. Dans la plupart des cas, nous avons donné, par voie endoveineuse, de 4 à 9 mg. de d-tubocurarine environ cinq minutes avant l'intubation.

Au moment de l'intubation, dans 50 pour cent des cas, le cœur s'est accéléré. Nous avons observé des changements dans le voltage, la vitesse et le rythme et, dans environ 60 pour cent des cas, ces changements électrocardiographiques sont apparus avant la laryngoscopie et l'intubation endotrachéale. A ce sujet, il est intéressant d'étudier le rôle des médicaments employés en prémédication et comme agents anesthésiques.

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THE EFFECT OF HALOTHANE ON THE LIVER OF DOGS EXPOSED TO MILD HYPOXIA[1]

FRANK C. HALEY, M.D., and GORDON M. WYANT, F.F.A.R.C.S.[2]

HALOTHANE was reported by Raventós in his original report (1) to have no hepatotoxic effects in animals when used in concentrations up to 1.2 per cent in air or oxygen. The first clinical reports by Johnstone (2) made no mention of hepatotoxicity nor did those of Chang (3), Hudon (4), MacKay (5), Robson and Sheridan (6), and Abajian (7). A note of caution was sounded by Stephen *et al.* (8). They reported that the chronic administration of halothane for a total of 24 hours spread over six days resulted in some central pallor in haematoxolin and eosin-stained sections of liver from dogs and monkeys. But they also stated that in humans halothane was less likely than other anaesthetic agents to produce liver dysfunction. Hall, Geisler, and Norris (9) reported the case of a patient exposed to a large amount of halothane with only slight congestion of liver and kidneys revealed at post-mortem examination. They felt that the drug had not contributed to the illness. Little and Barber (10) reported that halothane affected hepatic function less than cyclopropane or ether anaesthesia. Jones *et al.* (11) found halothane toxicity measured by intra-oesophageal instillation less than that of chloroform or divinyl ether, but greater than that of diethyl ether. Stephen *et al.* (12) conducted toxicity studies in dogs and reported a mild hepatotoxic action which again was much less than that of chloroform.

This study was undertaken to elucidate whether the combination of halothane with an inhaled gas mixture slightly deficient in oxygen might reveal any latent viscerotoxic properties of the agent, not apparent in the presence of adequate oxygen. Since mild degrees of hypoxia might occur during clinical anaesthesia for a variety of reasons, any significant effect of halothane under these conditions would markedly narrow its margin of safety.

METHOD

Four groups of mongrel dogs were studied. Each group consisted of six dogs weighing from 5 to 12.5 kg. and groups were matched for weight. All dogs were premedicated with 15 mg. of morphine and 0.6 mg. atropine intramuscularly at least 20 minutes prior to induction of anaesthesia. Induction was with 2.5 per cent sodium thiopental intravenously until the animals fell asleep, usually 25 to 30 mg./kg. This was supplemented as required with further thiopental while the dog was supine, the trachea intubated, a Silverman needle biopsy taken from the liver, and a femoral artery cutdown established. Mean arterial

[1]Presented at the Western Division Meeting, Canadian Anaesthetists' Society at Saskatoon, March 19–21, 1959.

[2]From the Department of Anaesthesia, University of Saskatchewan and University Hospital, Saskatoon.

blood pressure was measured by means of a mercury manometer connected to the arterial cutdown. This system was flushed with heparinized saline from time to time.

Each dog was given 3 hours of inhalation anaesthesia. Those in the first group received halothane with 20 per cent oxygen and 80 per cent nitrous oxide. The second group received halothane in 100 per cent oxygen. The third group was given halothane in 15 per cent oxygen and 85 per cent nitrous oxide and the last group received 15 per cent oxygen and 85 per cent nitrous oxide alone. Nitrous oxide and oxygen were delivered from a McKesson anaesthesia machine to the endotracheal tube through a Fink non-rebreathing valve. Halothane was delivered from a Fluotec vaporizer with concentrations adjusted in such a way that the mean arterial blood pressure did not fall below 100 mg. Hg. This resulted in a mean concentration of halothane of 0.8 per cent. When respiration became depressed, it was controlled by means of a Stephenson ventilator. This was set to deliver 15 mm. Hg pressure at inhalation, no negative pressure being possible with a non-rebreathing valve.

At the conclusion of 3 hours of anaesthesia, a second needle biopsy was taken from the liver and the cutdown and endotracheal tube were removed. In most cases the dogs were struggling by this time and were taken to the recovery cages. They were fed *ad lib*. All animals in this series were alive and well next morning. At two and seven days postoperatively they were re-anaesthetized with intravenous thiopental and liver biopsies were taken.

The biopsy specimens were fixed in formaldehyde solution, embedded in paraffin and cut at 8μ. Sections from all blocks were stained with haematoxylin-eosin and with PAS (periodic acid–Schiff method); some sections were also stained with Heidenhain's iron-haematoxylin.

The preparations were examined microscopically without knowledge of the treatment in each case, but the pre-anaesthetic specimen was known as such and served as normal control. It should be kept in mind that, owing to the procedure of needle biopsy, the architectural pattern of the specimens becomes distorted.

From the aspect of the cell body in the haematoxylin-eosin preparation, in which most of the fat has been dissolved out by the embedding and straining procedures, the fat content was assessed and the sections graded in an arbitrary way (+, ++, +++, ++++). Microphotographs reproduced in Figure 1 illustrate two different aspects, one from animal C-1, the other from animal C-6. It appears quite reasonable to state that in the paler cells more material has either been dissolved out or has not accepted the aqueous staining solutions. This material could be either fat or glycogen, or both. We believe we are justified in assuming that the main substance responsible for the pale staining in the haematoxylin-eosin preparation is fat. This view is supported by an examination of alternate sections, that is sections from the same blocks, stained with PAS. If the paleness and vacuolization of liver cells in the haematoxylin-eosin preparation were caused by the loss of glycogen during fixation and staining, the paleness and vacuolization in the haematoxylin-eosin preparation would be paralleled by a decrease of staining intensity in the PAS preparation. This

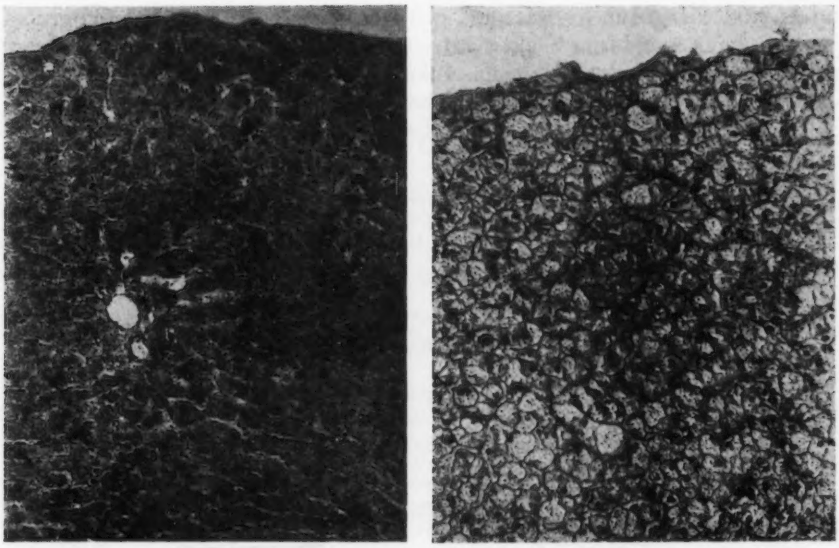

FIGURE 1. Haematoxylin preparation of liver of animals No. C-1 and C-6 (controls). Magnification × 166. Compare size of liver cells in the two figures as well as the intensity of staining. It is assumed (see text) that the pale cells contain more fat than the darker staining cells.

was not the case and, therefore, it appeared safe to grade sections stained with haematoxylin-eosin for increase or depletion of fat content, and sections stained with PAS for glycogen content.

We are aware that this procedure is not the most acurate. The alternative was to fix half of each small specimen in formaldehyde solution and stain frozen sections with Sudan IV or Sudan Black, whereas the other half of the specimen would have to be fixed in absolute alcohol, embedded in paraffin and stained by Best's carmin method. The disadvantages of these procedures on the small tissue fragments, many of which had become brittle due to admixed blood from unavoidable haemorrhages outweigh, in our opinion, the advantages and the slight risk of misinterpreting small differences in fat and glycogen content.

RESULTS

Comparisons were made difficult by the fact that, as might be expected, there was a marked variation in the fat and glycogen content between the various control liver specimens (Figs. 1 and 2). Hence, any changes must be interpreted as increases or decreases not from a common baseline but from the initial liver histology of any particular animal. Futhermore, the proximity or otherwise of the last feeding and a variable amount of ingested food before biopsy may show

up as mild changes in liver fat and glycogen. Hence, only marked differences between controls and later biopsies are significant.

The findings for fat and glycogen of the six animals in each of the four groups are graphically shown in Figure 2. The inconstant changes, usually within a narrow range, indicate that halothane has no more toxic effect on the dog liver

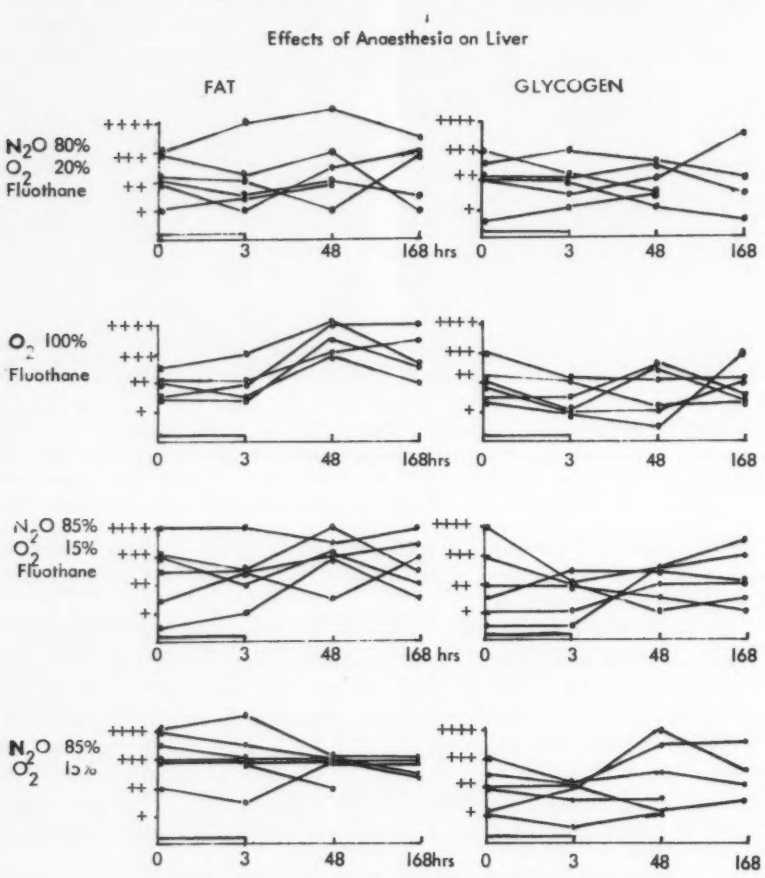

FIGURE 2. Summary of changes in liver fat and glycogen.

when administered in a hypoxic atmosphere than has the inhalation of the slightly hypoxic gas mixture alone. Indeed, if any trend is apparent at all, it is in the series of halothane in oxygen in which there was a consistent increase in the liver fat content. However, the average degree of this increase is still within the limits of normal variation and cannot be attributed therefore to the inhalation of halothane.

Except for one specimen, where there was what appeared to be a pathological vacuolization of liver cells, the body and nucleus of the parenchymal cells and of the sinusoidal cells showed no changes indicative of serious damage.

Summary and Conclusions

Halothane has been shown to have no effect on the liver histology of dogs exposed to the drug for 3 hours while adequately ventilated. The agent has no adverse effect on liver fat, glycogen, and cellular structure even when it is administered in an atmosphere slightly deficient in oxygen.

Acknowledgments

The authors are indebted to Dr. R. Altschul, Professor of Anatomy, who made the sections and interpreted them. Mr. K. Drummond, a medical student on an Abbott Research Grant, assisted with the investigations.

Résumé

Nous avons étudié quatre séries de six chiens chacune, chiens à poids égal deux à deux. Chaque chien a été soumis à une anesthésie de trois heures. Un groupe a reçu de l'halothane avec 80 pour cent de protoxide d'azote et 20 pour cent d'oxygène et un autre groupe a reçu de l'halothane avec oxygène seulement. Un troisième groupe a reçu de 85 pour cent de protoxide d'azote et 15 pour cent d'oxygène sans halothane. Nous avions pris des biopsies hépatiques avant l'expérience et nous en avons pris d'autres immédiatement après, 24 heures plus tard et sept jours plus tard. Sur les coupes, on a étudié les changements hépatiques en graisse et en glycogène. Nous n'avons pas trouvé de changements importants et, en conséquence, nous pouvons conclure que, dans les conditions expérimentales données, l'halothane ne produit pas de dommages sérieux sur l'histologie du foie.

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RITALIN® (METHYLPHENIDATE): CLINICAL EXPERIENCES[1, 2]

P. B. PERCHESON, M.D., F.R.C.P.(C),[3] JOHN J. CARROLL, B.A., M.D., C.M.,[3]
and GUY SCREECH, M.A., M.B., B.CHIR.[4]

METHYLPHENIDATE is a white, water-soluble crystalline compound. It is a piperidine derivative which can be administered orally, subcutaneously, intramuscularly or intravenously and is marketed under the name of "Ritalin" by Ciba Pharmaceuticals.

It is a behaviour-altering drug which is often included in the classification of tranquillizer or ataractic compounds (9). In contradistinction to the tranquillizers, however, its main pharmacologic action is stimulation of the mesencephalic reticular formations and accentuation of the arousal or alerting mechanism (8). This psychic stimulation of Ritalin has interested many investigators and it has been utlized to counteract barbiturate depression (1), (5), (6), (7), barbiturate (7) and non-barbiturate (3) poisoning and chlorpromazine (1), (4) and rauwolfia (2), (4) lethargy in psychiatric patients.

Gale (6) measured the effect of Ritalin on the recovery time of 272 patients who had a uterine dilatation and curettage performed under light pentothal and nitrous oxide anaesthesia. He reported that the optimum dose appeared to be between 0.1 and 0.2 mg./lb. This dosage was effective in shortening the recovery time to about one-half as compared to the controls. In a subsequent publication (5), he reaffirmed the above findings and suggested that dosages above 0.1 to 0.2 mg./lb. are less effective. He noted a mild transient rise in blood pressure, and occasional nausea and retching and emesis as the only side-effects of Ritalin therapy. He was favourably impressed with the effects of Ritalin on barbiturate-induced depression in the newborn infant.

Carter and Malley (1) studied the effects of Ritalin in 129 mentally retarded or brain-damaged patients who were classified into the following categories: (1) shock from chlorpromazine overdosage, (over 300 mg. T.I.D. for several days); (2) barbiturate poisoning and barbiturate anaesthesia; (3) moribund states such as severe pneumonia. They report beneficial results in all of these categories and mentioned that chlorpromazine overdosage responded more slowly and required higher doses of Ritalin. Their dosage ranged from 20 to 55 mg. intramuscularly and intravenously, repeated as often as every 20 min. to every 4 hrs.

Ferguson (2) administered 20 to 40 mg. of Ritalin orally to depressed psychiatric patients. He inferred that its main action was possibly in the thalamic area

[1]An abridgment of this paper was presented by the first author at the Canadian Anaesthetists' Society Annual Meeting, Montebello, Quebec, June, 1958.

[2]The Ritalin used in this series was kindly supplied by Ciba Pharmaceutical, Montreal.

[3]From the Departments of Anesthesiology of Vancouver Grace Hospital, Essondale Mental Hospital, and the University of British Columbia.

[4]From the Department of Anesthesiology of the Vancouver General Hospital, Wyeth Fellow in Anesthesiology.

because the effect on his patients was much like that of a lobotomy. He stated, however, that in most of the patients the slow awakening to reality elicited by the drug produced an element of confusion.

Ferguson and Linn (4) administered 10 mg. doses intravenously to 164 hospitalized mental patients who were drowsy and lethargic owing to large doses of tranquillizing drugs. Of these patients 160 showed improvement. However, eight out of the 164 became apprehensive and fearful after two to four injections of Ritalin and eight others became overactive. They claimed that these side-reactions were alleviated when dosage was decreased.

Ivey (3) successfully resuscitated a 35-year-old woman who attempted suicide by ingesting approximately 10 gm. of ethchlorvynol (Placidyl) and about 14 gm. of methyprylon (Noludar). He administered about 100 mg. of Ritalin intravenously in divided doses over a period of 3 to 4 hrs. He noticed marked improvement in the patient who had been in a coma for about 45 hrs., and had become moribund despite intensive supportive treatment which included electrostimulation, caffeine sodium benzoate, and metrazol. He noted that Ritalin potentiated the pressor effect of the levarterenol (Levophed) drip which was necessary throughout the supportive treatment of the patient.

Plummer and Yonkman (8) noted that Ritalin potentiated the pressor effect of norepinephrine but antagonized the hypertensive action of amphetamine and ephedrine.

Smith and Adriani (7) were impressed with the analeptic effects of Ritalin on barbiturate depression and barbiturate poisoning. They noted several side-effects in the 33 subjects treated with Ritalin for barbiturate depression. These were listed as nausea in seven, disorientation after recovery in six, and garrulousness in eight. The dose of the drug in these cases was based on 0.2 mg./lb. body weight. The 26 cases of barbiturate poisoning required from 60 to 1,100 mg. of Ritalin for resuscitation.

Our interest in Ritalin was stimulated by the anticipation that its unique analeptic properties would be of great value to the anaesthesiologist in (i) reducing the time spent by the patient in the recovery room, (ii) expediting the recovery from dental office procedures done under general anaesthesia, and (iii) counteracting the barbiturate depression of the newborn when such sedation is administered to the mother during labour. With regards to the last of these, we are convinced that even small doses of barbiturates have a prolonged depressing effect on the newborn. Adelman (10) and Duchesne (11) have been similarly impressed with the depressant effect of barbiturates on the infant. As a result, we have practically eliminated the use of barbiturates in our hospitals and have been administering such drugs as promethazine (Phenergan) (12), (13) and meprobromate (Equanil) for sedation during labour. In our experience, these drugs have no apparent depressant action on the baby, and thus, the trial of Ritalin in our obstetrical patients has not been warranted.

However, we studied the analeptic effects of Ritalin on 60 patients. Of these patients 52 had gynaecological surgery as follows: (1) 40 patients had a dilatation and curettage performed under surital (500 mg.) and nitrous oxide/oxygen

(6/2) ratio in a semi-closed circuit; (2) 6 patients had the same procedure performed under intravenous Nembutal (150 to 250 mg.) plus syncurine 2 mg. plus nitrous oxide/oxygen in a 6/2 ratio; (3) 6 patients had longer gynaecological procedures performed under spinal (Pontocaine) and sleep dose of intravenous Nembutal (150 to 250 mg.). All of these patients were premedicated with Pantopon 10 mg. and hyoscine 0.2 mg. In three patients, promethazine 25 mg. was added to the above premedication.

At the termination of the surgical procedure, Ritalin, in doses of from 10 to 60 mg., was injected intravenously. The times taken to respond to painful stimuli, eyelid stimulation, and verbal command, and time of wakefulness as judged by purposeful movement and speech were recorded and compared to a control group to whom Ritalin was not given.

As shown in Table I which gives awakening times in 12 unselected cases and 12 controls, our results compare favourably with those of Gale (5, 6). Judging from the response to painful stimuli, the Ritalin series shows a response time of 2.3 minutes (average) as compared to 8.2 minutes (average) for the controls.

TABLE I

Patient no.	1	2	3	4	5	6	7	8	9	10	11	12
Ritalin (mg.)	60	40	20	20	20	10	10	10	20	20	20	20
Time of pain response (min.)	5	5	2	2	2	2	1	1	2	3	2	1
Control patient no.	13	14	15	16	17	18	19	20	21	22	23	24
Time of pain response (min.)	15	11	3	6	11	7	8	7	12	3	9	6

Thus the advantages of Ritalin may be summarized as follows:

(i) Ritalin definitely accelerates wakefulness of patients anaesthetized or depressed with intravenous barbiturates.

(ii) This awakening state is not transitory but appears to persist for some hours.

(iii) The action of the drug suggests independent central nervous system stimulation rather than biological competition with depressant drugs.

(iv) A dose of 10 to 20 mg. produces a state of alertness which allows gentle sleep from which the patient is readily rousable by the spoken voice. Larger doses seem to preclude sleep for 4 to 6 hrs. afterwards.

(v) An average rise of about 10 mg. mercury of systolic pressure was noticed within 1 minute of the Ritalin administration, but pulse rate and respirations were unaffected.

(vi) The three patients who received promethazine 25 mg. as additional premedication showed delayed awakening times despite the larger doses (40 to 60 mg.) of Ritalin.

Side-effects

Gale (6) listed as side-effects a mild transient rise in blood pressure and occasional nausea, retching, and vomiting. Ferguson (2) mentioned a period of confusion following the administration of Ritalin to psychiatric patients. However,

Smith and Adriani (7) found that a high percentage of their patients showed disorientation, nausea, and garrulousness.

Our incidence of side-effects was considerable and some of them were quite disturbing to the patient, the anaesthesiologist, and the nurses on the surgical ward.

Most of the patients in this series of 52 were restless for 2 to 3 hrs. after return to full consciousness and the nurses quickly got to recognize those who had received Ritalin. Three young healthy females who were given Ritalin following dilatation and curettage performed under surital and nitrous oxide-oxygen anaesthesia were fully conscious within 3 minutes. Two of these received 10 mg. of Ritalin and the other 20 mg. intravenously. Upon return of consciousness, they became euphoric, noisy, and restless for several hours. They were serious nursing problems in that they constantly tried to get out of bed though they lacked the muscle co-ordination to even stand up. Two complained of severe headache despite normal blood pressures, and the following day each described her recovery as a most unhappy experience. They stated that they were aware of their actions but were unable to control them.

Another such healthy female was given 60 mg. of Ritalin at the end of a dilatation and curettage performed under surital–nitrous oxide–oxygen. She awakened within 3 minutes, but became hysterical. Her blood pressure rose from 130/80 to 160/90, but pulse and respirations remained unaltered. She complained of severe headache, thrashed around in her attempts to get out of bed, and had to be restrained for 3 hrs. and watched carefully the rest of that day. The next day she had a clear recollection of her recovery period but insisted that she was unable to control herself.

About 10 per cent of these patients had restless postoperative nights which did not respond well to the usual sedation. Other side-effects such as diploplia, vomiting, and milder forms of restlessness and headache were observed in several patients, but these were of no consequence.

In addition to the above-mentioned 52 cases, we used Ritalin in four dental cases who had been anaesthetized with pentothal–curare–nitrous oxide–oxygen and trilene; three elective neurological cases who had craniotomies performed under the "lytic cocktail," and had received on the average chlorpromazine 200 mg., promethazine 200 mg., and Demerol 300 mg.

One of the four dental procedures was done on an apparently healthy young man. He received 20 mg. of Ritalin intravenously following the procedure and awakened immediately in a very disturbed state. He was able to walk over to the recovery-room bed and responded briskly to verbal command but persisted in reliving some events pertaining to his war experience. This lasted for 5 hrs., and he had to be restrained for most of the time. We had never seen this type of emergence delirium last for such a long time with the type of anaesthesia administered, and thus Ritalin must be suspected.

Ritalin appeared to raise the level of alertness in the three neurological cases done under the "lytic cocktail" and nitrous oxide–oxygen. The response was much less dramatic and full consciousness did not return in these patients until several

hours later. In one such patient who was on a Levophed drip, the administration of 60 mg. of Ritalin intravenously appeared to drop the pressure from 80/50 to 60/40. However, increasing the drip rate of the Levophed did restore the blood pressure rapidly. In view of the reports of Plummer and Yonkman (8) and Ivey (3), we are not prepared to comment upon or explain this phenomenon.

We used Ritalin in one case of barbiturate poisoning. A young woman was admitted to hospital in a comatose, cyanotic, and shocked condition after having ingested an unknown amount of Tuinal. Blood pressure was not recordable, pulse barely palpable, and her respiratory movements were reduced to diaphragmatic gasps. She was given 40 mg. of Ritalin intravenously and within a few minutes her colour became pink, her blood pressure recorded at 100/60, her pulse became strong and her respirations returned to normal. She required no further treatment and was discharged from the hospital 12 hrs. later apparently having suffered no ill effects.

Summary and Conclusions

In our experience, Ritalin is effective in antagonizing the actions of barbiturates. The action does not appear to be a specific antagonism but rather an independent central nervous system stimulation which raises the level of alertness or wakefulness. In moderate doses it has little effect on the blood pressure, pulse, and respirations. In larger doses, it would appear to increase the blood pressure without affecting the pulse and respirations. In our one case of severe depression from barbiturate poisoning, it rapidly returned all three to normal.

The high incidence of euphoria, restlessness, mental agitation, and headache following its administration in moderate doses would seem to preclude its routine use for hastening recovery from barbiturate anaesthesia. However, in instances of severe depression from such drugs, Ritalin therapy appears to be safe and effective and its side-reactions become minor considerations.

Résumé

La Ritaline est efficace pour lutter contre l'action des barbituriques. L'action ne semble pas consister en un antagonisme spécifique mais en une stimulation indépendante du système nerveux central qui élève le niveau de la vigilance et du réveil. A doses réduites, elle a peu d'effets sur la tension artérielle, le pouls et la respiration. A doses plus considérables, il semblerait qu'elle augmente la tension artérielle sans changer le pouls ni la respiration. Dans un cas de dépression grave par empoisonnement barbiturique, elle a ramené rapidement les trois à la normale.

L'observation fréquente d'euphorie, d'agitation physique et mentale, de céphalée à la suite de son administration à doses réduites, plaiderait contre son usage routinier pour accélérer le réveil après l'anesthésie aux barbituriques. Toutefois, dans les cas de dépression grave par ces médicaments, le traitement à la Ritaline nous semble efficace, de toute sécurité, et ses effets secondaires deviennent négligeables.

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AN AID TO GENERAL ANAESTHESIA FOR BRONCHOGRAMS

M. W. Bowering, C.D., M.D., F.A.C.A.

General anaesthesia for bronchograms at Regina General Hospital has been greatly simplified by a modification of a technique published by Dr. A. H. L. Baker in the *British Journal of Anaesthesia* (1).

The anaesthetic agents we have been using are thiopentone, succinylcholine by drip, and nitrous oxide. After induction the patient is intubated using a cuffed endotracheal tube or a snug tube in children. This endotracheal tube is fitted with a Cobbs Suction endotracheal connector. In addition to the regular solid plug for the suction inlet, Dr. E. Asquith has designed and machined plugs fitting the suction inlet which are drilled with a hole that accommodates a fair sized polyethelene tube without binding or leak. As unfortunately the suction inlets of all Cobbs Connectors are not uniform in size, this plug must be tested for fit to the Cobbs Connector before use.

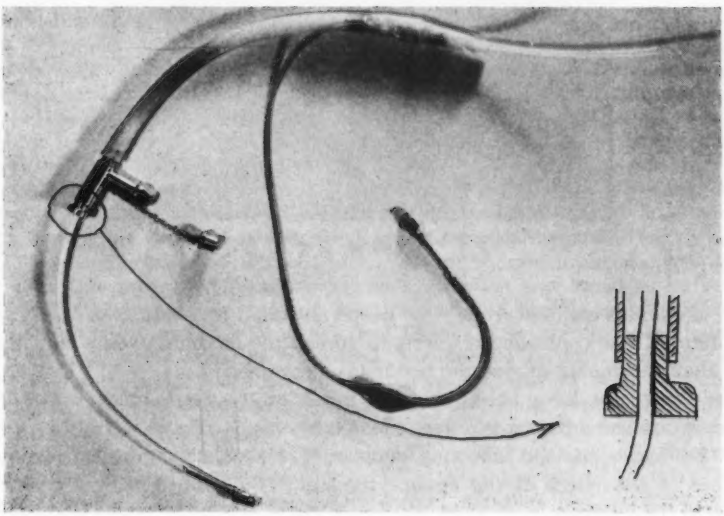

Figure 1

The polyethelene tube is several inches longer than the endotracheal tube and connector and is fitted on the external end with a round-based needle to fit the injecting syringe or suction tubing. Prior to use of this plug and tube, the tube is filled with opaque medium. With the patient almost apnoeic, the modified plug and tube are substituted for the solid plug of the Cobbs Connector, and the polyethelene tube is manipulated under fluorscopy to the area in which it is desired to place the medium.

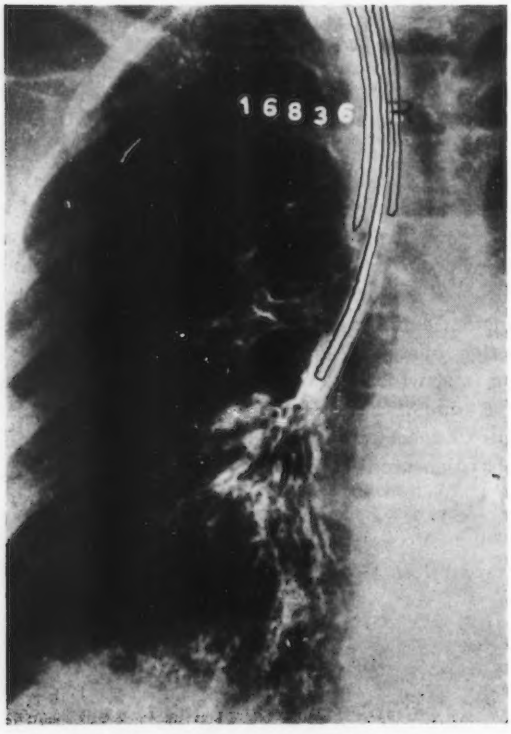

FIGURE 2

The medium is instilled while slow deep controlled respirations are imposed on the patient. These controlled respirations spread the medium evenly and we have found that the amount of medium needed is minimized.

After the plates have been taken, as much of the medium as is possible is suctioned out, using the same polyethelene tube.

This technique has the following benefits: (1) absolute control of respiration; (2) ease of placement of the opaque medium; (3) ease of recovery of a proportion of the medium.

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VAGUS AND GLOSSOPHARYNGEAL NERVE PARALYSIS: CASE REPORT[1]

M. Keéri-Szántó, M.D., and M. Belzile, M.D., M.S. (N.Y.U.)[2]

Disturbances of cranial nerves following general anaesthesia are rare and, of all the cranial nerves, the vagus is least frequently involved (5). The following case appears, therefore, to be worth reporting since it concerns extensive bilateral involvement of the ninth and tenth nerves in all their aspects, sensory, motor, and autonomic.

Case Report

A 35-year-old well-nourished male entered the neurosurgical service of the hospital with a five-year history of headache. Several years before he had a questionable cerebrovascular accident which cleared up completely. Angiographic study, carried out uneventfully under general anaesthesia, revealed a "left frontal space-occupying lesion." History and laboratory findings were otherwise non-contributory.

Craniotomy was scheduled for the day following angiography. Anaesthetic induction and intubation were uneventful with thiopental and suxamethonium, producing no change in systolic blood pressure (150 mm.Hg) and pulse rate (100/min.). Respirations were manually controlled. Twenty-five minutes after the start of anaesthesia, the patient was turned on his side for placement of a spinal needle. During this manipulation he coughed lightly twice. Anaesthesia was immediately deepened with more thiopental. It was noted that the systolic blood pressure rose to 170 while the pulse rate dropped to 70. Installation was completed 50 min. after starting the anaesthesia and preparation of the surgical field was started. About 60 cc. of a 0.4 per cent dibucaine solution with 3 drops of adrenalin 1:1,000 to 100 cc. were injected into the scalp. Simultaneously, the patient was connected to a mechanical respirator and was given 100 mg. gallamine tri-iodide intravenously. Vital signs were again checked as soon as installation was completed and the patient's condition was found to be radically changed. The blood pressure rose and soon reached 240 mm.Hg and the pulse rate mounted from 65–70 to 180/min. in less than 10 min. The surgeons were alerted and surgery stopped as the skin flap was raised. Twenty minutes after the onset of the hypertensive episode, his blood pressure started to drop sharply with the pulse rate remaining at 170/min. Vasopressors and whole blood under positive pressure were administered as the systolic pressure dropped below 100 mm.Hg and the patient was given 100 per cent oxygen via the respirator. His colour remained excellent and his skin warm and dry, but, in spite of all efforts, his pulse disappeared 30 min. after the onset of difficulties. Some time was lost convincing ourselves that cardiac arrest had occurred because his colour was still excellent. When finally a skin incision was made over the thorax, bleeding was noted from the wound and a few seconds later the pulse returned, making it unnecessary to open the chest. The pressure soon stabilized around 80 mm.Hg and the pulse rate at 120/min. The chest incision was closed and

[1]The authors are indebted to Dr. C. Bertrand, F.R.C.S.(C) for referral of his patient and for his interest and helpful criticism in the preparation of this manuscript.

A preliminary report of the anaesthetic aspects of this case was published anonymously in the A.S.A. monthly Newsletter (No. 200); the comments of several anaesthesiologists, appearing subsequently in the same journal, are gratefully acknowledged.

[2]From the Anaesthesia and ENT Services of Notre Dame Hospital, Montreal.

the patient was observed for a time. Since there was a possibility that the brain had herniated, it was finally decided to carry on. The brain was first visualized about 1 hr. after the circulatory arrest and showed none of the usual signs of herniation, though ventricular pressure was higher than normal. In the course of a 5¾-hour operation, a cystic meningoblastoma was removed from the left fronto-parietal region. The anaesthetic course was without further incidents. The patient was extubated 10 min. after the end of surgery: at that time he obeyed spoken commands and answered questions. On the evening of the same day he recognized people whom he had only met just before surgery. He was quite hoarse. The following day his voice became worse and he was somewhat confused. Then, 48 hrs. after surgery, it was first noticed that the patient was unable to swallow and aspirated everything he took by mouth. Laryngological examination revealed bilateral motor paralysis of the ninth and tenth nerves, complete anaesthesia of the root of the tongue and the larynx, with diminished sensation of the bronchial mucosa. Additional findings were a right Horner's syndrome, "jelly"-nystagmus and left hemianopia, left facial nerve paresis, and persistent tachycardia, between 120 and 140/min. Diarrhoea was not noted at any time. In view of the fact that bronchial aspiration was easily performed in this patient, he was put on tube feeding and tracheotomy was delayed until almost three weeks after surgery when there appeared no trace of recovery of the laryngeal reflexes. His general course was otherwise quite satisfactory and he was discharged from the hospital four weeks after surgery. At the time he was still unable to swallow, had to be tube-fed, and his pulse remained around 100/min. at rest.

The patient started to regain control of his pharynx and larynx about two weeks after his discharge. At present (12 months after surgery), his tracheotomy is closed, his laryngeal sensations have returned, and he swallows well. With a still paralyzed left vocal cord and left pharyngeal musculature, he has made a full functional recovery. He has slight rotatory nystagmus and almost complete left hemianopia which have been stationary for the past six months. His pulse is now in the high normal range and his exercise tolerance is excellent. He has returned to his previous job in a brokerage firm.

Comment

The case history suggests a brain-stem lesion involving mostly the nuclei of the ninth and tenth nerves. The lesion was initially bilateral and receded in the course of a few months until it now appears permanent and sharply localized.

In animal experiments high section of both vagi causes pulmonary oedema and is rapidly fatal. The resistance of such animals against adrenalin is sharply reduced (9).

In humans (1, 2, 3, 4) the transected vagus nerves were usually diseased and in only one instance (2, 4) were both vagi cut. Tachycardia is a constant feature in these reports, subsiding some time after surgery except where both nerves are cut. Hypertension has not been noted. For the sake of completeness, one should also mention that there is good experimental evidence for sensory representation of the larynx in the reticular substance and the cortex (6, 7). Some authors also postulate a higher laryngeal centre in the same sense as the oculomotor system (8, 10).

Our patient evidently suffered a transient and unusually severe haemodynamic upset following a rather banal incident during installation. He had a peculiar involvement of the cranial nerves which lasted for several weeks and he now

apparently has permanent residual lesions which can be localized to the left nucleus ambiguus, the oculomotor system, and the left visual cortex. Chances are overwhelmingly against the possibility that these lesions occurred independently of each other. The haemianopia is certainly due to anoxia, which in turn was brought on by the tachycardic episode. What explanation can be offered for the latter?

Surgical trauma cannot be considered more than an aggravating factor because the difficulties started before surgery got under way. Thus, the initial insult during installation was most probably caused by anoxia of a small cluster of cells and hypoxia of a larger surrounding area. This precarious equilibrium was prolonged for several days owing to the inevitable cerebral oedema after brain surgery. It caused sufficient anatomical damage to require relearning of reflex pathways and compensation for the paralysed muscles by the remaining active elements. This would account for the unusually long interval between injury and recovery. Alternatively, the prolonged recovery may be explained by damage to the supranuclear pathways and centres during surgery added to the anatomical lesion produced during installation.

On this basis the following might have been the sequence of events. At the time of positioning, the rostral portion of the left nucleus ambiguus and the left solitary tract nucleus became either compressed or otherwise deprived of their blood supply. It is impossible to say what rendered this usually well-protected area vulnerable in our patient. The break in the cardio-regulatory servo-loop, involving these synapses and the left carotid sinus, suddenly abolished the cardio-inhibitor efferent vagal impulses. Simultaneously adrenalin was injected into the thus sensitized (9) patient. The resulting tachycardia and hypertension could explain the ensuing circulatory failure through sheer myocardial exhaustion. During the postoperative stage cerebral oedema increased the size of the brain-stem portion where the blood supply was marginal. This lamellar area now involved the contralateral ninth and tenth nuclei as well, while the twelfth nerve nuclei (located between the opposite ninth and tenth nuclei but in more dorsal plane) remained intact. As the cerebral oedema subsided and the blood supply of the area stabilized, a reintegration of laryngeal and pharyngeal functions began, leading in a few months to full compensation for the permanently paralysed elements.

It is appreciated that it is not conclusively proven that vagal or glossopharyngeal paralysis was complete at any time in our patient. Nevertheless the scarcity of reports about the paralysis of these nerves in humans and the peculiarities of the postoperative course in this subject might justify its recording.

Summary

Following essentially normal induction and installation for craniotomy, a 35-year-old male developed paroxysmal hypertension and tachycardia which culminated in cardiac standstill. Prompt initial recovery was followed postoperatively by complete motor and sensory paralysis of the larynx and pharynx as

well as persistent tachycardia. These symptoms continued for six weeks and the eventual full functional recovery took several months. The accident is tentatively explained in terms of paralysis of the ninth and tenth nerves and the pertinent literature is reviewed.

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CORRESPONDENCE

416 Golf St.
Bathurst, N.B.
February 5, 1959

Editor
Canadian Anaesthetists' Society Journal

DEAR SIR:

The short-needle technique in brachial plexus block as outlined by Dr. Fortin and Dr. Tremblay (this JOURNAL, vol. 6, no. 1, January, 1959, pp. 32–39), appears to have several advantages over orthodox methods practised today.

However may I be allowed to bring up the following points:

(1) Test aspiration for blood through such small needles is in my opinion unreliable and the injection of the entire volume of solution in one spot increases the danger of intravascular injection. On the other hand, to insist on obtaining paraesthesias and "freezing" the needle in position as soon as these are obtained would seem to protect against this.

(2) As emphasized by Sir Robert Macintosh in his book *Physics for the Anaesthetist*, much pressure is needed to force solutions through small gauge needles. This makes a smaller Lock syringe with finger rings mandatory. Reloading the syringe twice will tend to disturb the position of the needle.

(3) Of course, the authors do not mean that the concentration of epinephrine in the average volume of 24.5 cc. is 1:2,000. Otherwise how do they keep the top of the patient's head from blowing right off.

Yours respectfully,

J. CARON, M.D.

Notre Dame Hospital
Montreal, P.Q.
March 11, 1959

Editor
Canadian Anaesthetists' Society Journal

DEAR DR. GORDON:

Thank you for the copy of Dr. Caron's letter. This provides us with a wonderful opportunity to give additional information on the "Short Needle Technique in Brachial Plexus Block" (this JOURNAL, vol. 6, no. 1, January 1959, pp. 32–39).

In answer to Dr. Caron's first question, we have had no difficulty in drawing blood experimentally from arteries and veins with a ½ in. 26-gauge needle. Test aspiration with longer small gauge needles is less reliable.

The possibility of transfixing a blood vessel is always present, in which event tissue displacement or needle movement may cause the needle point to slip back into the lumen of the vessel. Frequent test aspirations during the injection of the

entire volume of solution in one spot will guard against massive intravascular injection.

Dr. Caron's second objection with regard to reloading the syringe is quite legitimate. Indeed, applying Pascal's principle of the hydraulic press in reverse, the smaller the needle gauge and the larger the cross-sectional surface area of the syringe barrel, the smaller the mechanical advantage and, therefore, the greater the force required to inject. We have found that a 10 cc. syringe is the largest syringe which will allow a free flow through a 25-gauge ½ in. needle without applying too much force. Unfortunately, this necessitates reloading the syringe and care must be taken not to displace the needle during this manœuvre. A specially designed needle shank fitted with extensions to firmly hold the needle between the fingers would help.

We are particularly grateful to Dr. Caron for calling our attention to the concentration of epinephrine in the anaesthetic solution. On page 35, in the third paragraph of the article, the concentration of epinephrine in the Xylocaine® solution is stated as 1:2,000. *This should have read 1:200.000.*

The recommended 1.5 per cent Xylocaine® solution with an epinephrine concentration of 1:200.000 to our knowledge is not commercially available. This is obtained by mixing equal parts of a 1 per cent solution and a 2 per cent solution, one containing epinephrine 1:100.000, the other without epinephrine.

Since the article was published, we have witnessed one incident of needle breakage. Although the needle was recovered without difficulty, this type of complication could have caused an embarrassing situation to say the least. In this particular case, a 26-gauge ½ in. needle was used for the block procedure instead of a 25-gauge needle as recommended. Furthermore the needle had already sustained a bending stress and was not discarded. Unless one has thoroughly mastered the technique of needle manipulation, it may be an added precaution to recommend the use of a 24-gauge ½ in. needle.

Sincerely,

GUY FORTIN, M.D.
LIONEL TREMBLAY, M.D.

611 North Arden Dr.
Beverly Hills, Calif.
January 27, 1959

Editor
Canadian Anaesthetists' Society Journal

DEAR DR. GORDON:

In the January, 1959 (vol. 6, no. 1) issue of the *Canadian Anaesthetists' Society Journal*, I culled the following information from page 79 of the paper on "Cardiac Resuscitation" by Dodds and Ashmore. "The ventricles are shocked by placing the electrodes across the septum and a single shock of *170–220 v.* at 1.5 amp. for 0.2 sec. is used." Beattie *et al.* (Ann. Surg. *137*: 504) in 1953 reported

the resistance of the human heart to be approximately *50 ohms*. According to Ohms Law, $I = E/R$ or Amperes = Volts/Ohms, it is impossible to have a voltage of 170–220 v. with a resistance of 50 ohms and obtain an amperage of 1.5 amp. If you substitute the above underlined values in the formula the following values are obtained: $170/50 = 3.4$ amp., $220/50 = 4.4$ amp. Therefore, would you please ask Drs. Dodds and Ashmore what they recommend.

Very truly yours,

BENJAMIN I. SCHNEIDERMAN, M.D.

The Vancouver General Hospital
Vancouver 9, B.C.
February 27, 1959

Editor
Canadian Anaesthetists' Society Journal

DEAR DR. GORDON:

In answer to the letter received from Dr. Schneiderman, Beverley Hills, I would say that the article by Beattie and Blades relating to the resistance of the human heart indicates that this measurement is very difficult to make. The figure of 50 ohms was arrived at by an indirect method by comparing the resistance in the live and dead dog's heart to that in the dead human heart. Also, it is believed, that any amperage below 1.0 is a fibrillating, rather than a defibrillating current. Since defibrillation is often required for large hearts due to dilatation or hypertrophy, it has been found that 170 to 220 v. is a range which will deliver over 1 amp. in any human heart that we have yet encountered.

Electrical resistance in the human subject is difficult to gauge clinically and for purposes of cardiac defibrillation the resistance must be assumed to be greater perhaps than it is, so that adequate current will be delivered. I hope this will clear up Dr. Schneiderman's difficulty.

Yours sincerely,

W. A. DODDS, M.D.

OBITUARY

Frederick Arthur Harvey Wilkinson

Former students and colleagues across Canada will learn with regret of the death of Arthur Wilkinson on April 7, 1959. Arthur underwent surgery at the Royal Victoria Hospital in December, 1958, and then learned that he must face a progressive and incurable condition. He accepted the situation with great courage and until shortly before his death, enjoyed the comradeship of his friends, discussing the past and the future of anaesthesia.

Arthur Wilkinson, the son of a minister, was born at Sawyerville, Quebec, in 1906 and as his father moved from parish to parish, attended schools at Prescott and Perth, Ontario. He taught school for one year before entering the Faculty of Arts at McGill. He then proceeded to Medicine and graduated from McGill in the class of 1933. Following a rotation year at the Royal Alexandra Hospital in Edmonton, he commenced his training in anaesthesia at the Royal Victoria Hospital, Montreal, under Dr. William Howell. In 1936 he acquired further training in England and was the first Canadian to write the examinations for Diploma in Anaesthesia of the Royal College of Physicians and Surgeons of England.

Following his return to Montreal he was appointed to the Attending Staff of the Royal Victoria and Demonstrator in Anaesthesia at McGill University. In

1944, Anaesthesia became a full department at the Royal Victoria and Dr. Wilkinson became the first Anaesthetist-in-Chief. He was later promoted to Assistant Professor.

Arthur was a skilled and competent anaesthetist and a master of spinal techniques. He was an excellent practical teacher and many of us will always remember his patient instruction. During the Second World War, he supervised a large and active programme, trained residents and many medical officers of all three services. He later served faithfully and actively as President of the Quebec Division of the Canadian Anaesthetists' Society, and as an examiner of the Royal College of Physicians of Canada.

After a period of prolonged ill health, he requested retirement in 1955 and was appointed to the Honorary Consulting Staff. With fewer responsibilities, he was able to enjoy his small home in the country and frequently turned up at meetings to chat with his colleagues.

Arthur Wilkinson will be remembered as a diligent contributor to his specialty and a faithful servant of the Royal Victoria Hospital. He leaves his mother and two brothers, all of Montreal.

A. B. NOBLE, M.D.

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Cost of the course is $35.00. Lectures will be given at the Montreal Neurological Institute. Cafeteria services are available at the Royal Victoria Hospital. Advice can be given concerning hotel and lodging accommodation, on request.

If you are interested, please send for a programme.

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Canadian Anaesthetists' Society Journal

In order that subscribers and libraries may obtain them, the Society wishes to repurchase copies of the following issues of the Journal at $1.00 per copy: Vol. V, 1958, Nos. 2, 4 (April, October). Copies must be complete and unmarked, and should be forwarded to the Secretary, Canadian Anaesthetists' Society, 178 St. George St., Torono 5, Ontario.

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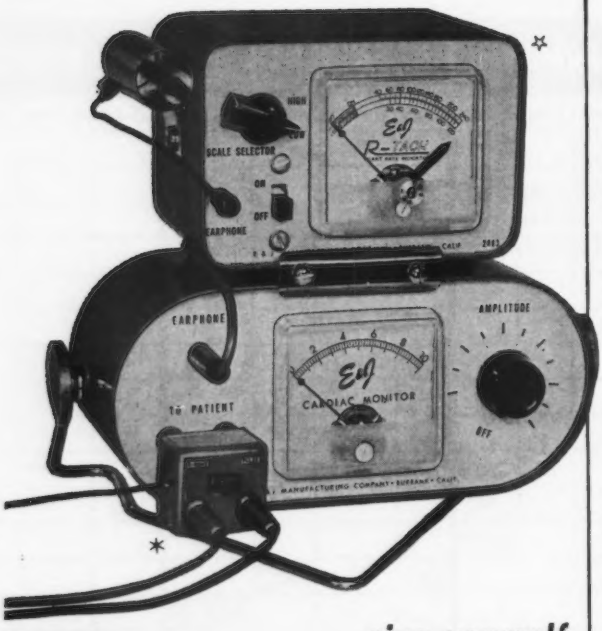

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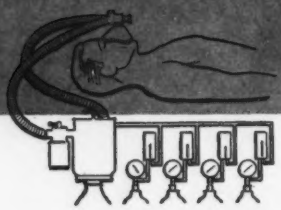

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CARDIAC ARREST— PREVENTION, DIAGNOSIS AND TREATMENT

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After defining cardiac arrest as a "cessation of effective circulation," the author discusses its causes, prevention, diagnosis and treatment.

CAUSES: Cardiac arrest is caused basically by respiratory (lack of oxygen and/or excess carbon dioxide in the alveoli) or cardiovascular factors. The author describes several situations which commonly bring about cardiac arrest.

PREVENTION: Signs and symptoms of impending arrest are discussed and the author describes various apparatus used to detect these signs, mainly the electrocardiographic monitor. Normal and abnormal patterns as they appear on apparatus screens are illustrated and audio monitoring described. Prevention is obviously the best treatment.

DIAGNOSIS: The ability to instantly detect cardiac asystole or ventricular fibrillation is a most important function of an electrocardiographic monitor. Correct interpretation of audio and visual monitors by the operating room team is vital.

TREATMENT: Successful treatment of cardiac arrest depends on early recognition and immediate institution of definite therapy. Both the surgeon and anaesthesiologist are needed and must act quickly.
The author concludes by emphasizing the vital role played by the anaesthesiologist in prevention, diagnosis and treatment of cardiac arrest. He mentions the Dallons Cardioscope as a recommended unit for observing the patient's electrocardiographic status.

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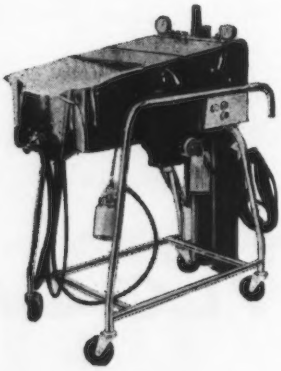

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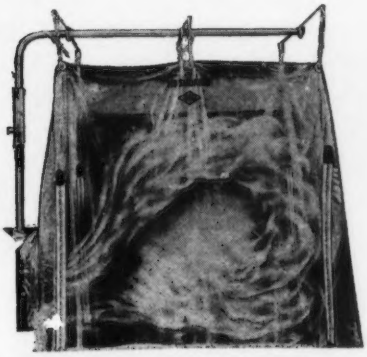

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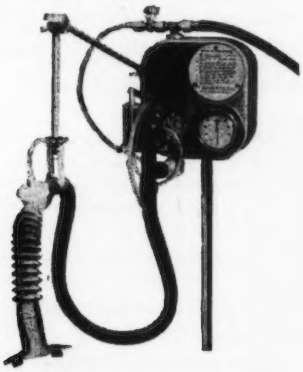

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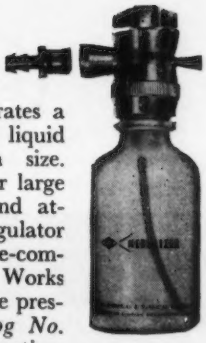

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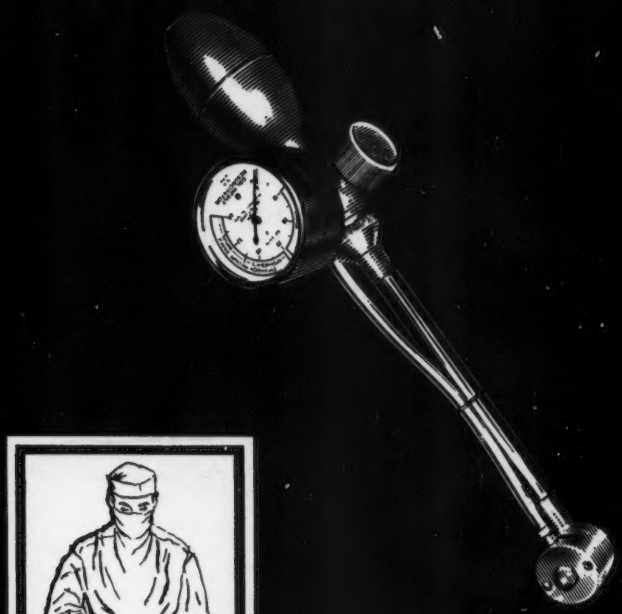

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THE SECOND WORLD CONGRESS OF ANAESTHESIOLOGISTS

and Assembly of

The World Federation of Societies of Anaesthesiologists

TORONTO, CANADA

SEPTEMBER 4 to 10, 1960

Communications should be addressed to

The Chairman
Organizing Committee
World Congress of Anaesthesiologists
178 St. George Street
Toronto 5, Ontario

THE SECOND WORLD CONGRESS OF ANAESTHESIOLOGISTS

TORONTO, CANADA

SEPTEMBER 4 to 10, 1960

GENERAL INFORMATION

The Second World Congress of Anaesthesiologists will be held at the Royal York Hotel, Toronto, Ontario, Canada, from September 4th to 10th, 1960. This quinquennial function of the World Federation of Societies of Anaesthesiologists will be convened under the auspices of the Canadian Anaesthetists' Society, as host. The Congress will be open to all physicians interested in Anaesthesiology.

SCIENTIFIC PROGRAMME

The Scientific programme, divided into plenary and concurrent sessions, will extend from Monday, September 5th, to Friday, September 9th, 1960.

The Programme Committee invites contributions to the scientific programme in the form of reports on current clinical investigation, basic research, teaching of anaesthesia and organization of departments.

The Committee is anxious to receive papers from all countries, but it is necessary to strictly limit presentations for the plenary sessions to twenty minutes including presentation of slides or brief illustrative movies, and to ten minutes for the concurrent sessions.

Discussion of the twenty-minute papers will be limited to two five-minute periods by designated speakers and there will be no discussion of the ten-minute presentations.

Submission of Papers—Those offering papers for consideration should complete an Application Form and return it with an abstract of 250 words to reach this office by December 31st, 1959. The full text of the paper must be submitted in quadruplicate by March 31st, 1960.

Panel Discussions on selected subjects will be arranged.

Cinema Exhibits—There will be a special room for continuous showing of films on anaesthesia. Those offering films for consideration should complete an Application Form which should reach this office not later than December 31st, 1959.

Official languages will be English, French, German and Spanish and simultaneous translation will be provided at all sessions.

Forms may be obtained from

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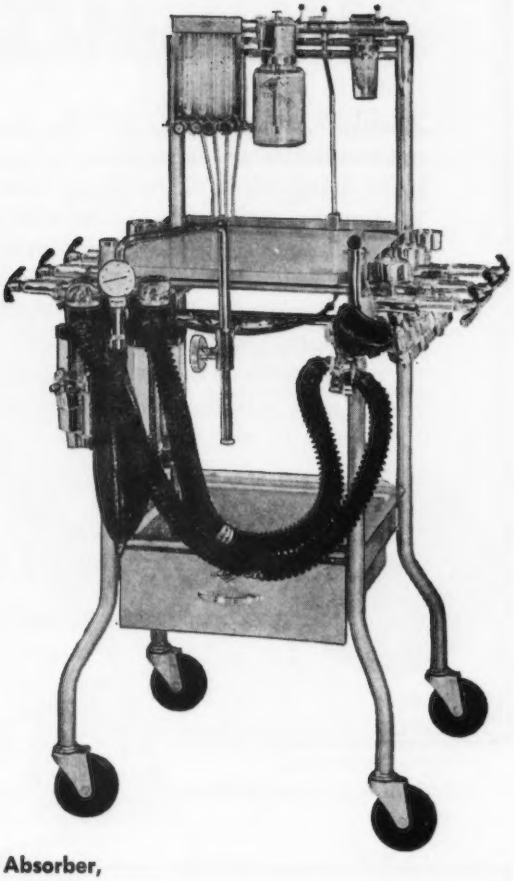

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1. Webster, C.W., C.M.A.J. Oct. 1953.

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THE CANADIAN ANAESTHETISTS' SOCIETY JOURNAL

Editorial Policy

The Canadian Anaesthetists' Society Journal is published quarterly by the Canadian Anaesthetists' Society Inc. Original articles are accepted for publication on the understanding that they are contributed exclusively to this journal and become the property of the Canadian Anaesthetists' Society. Articles are subject to such alteration as the Editor in his absolute discretion may deem necessary, but no major alterations will be made without consent of the Author.

Manuscripts

Articles should be typewritten in double space on one side of the paper only. Pages must be serially numbered, and each page should carry at its head the name of the author and the title of the article in full or in an appropriate abbreviation. The article should be concluded by a summary which will be intelligible without reference to the main text. All articles should be accompanied by a résumé presenting the important features in short form, for translation into the French language. French-speaking authors should provide this résumé in the French language.

References to the literature should be clearly indicated in the text by arabic numerals in brackets, thus (4). They should be set out in numerical order at the end of the article, typed in double space, as follows:

4. Griffith, H. R. & Johnston, G. E. The Use of Curare in General Anaesthesia. Anesthesiology 3: 481 (1942).

References to books will state in order: Name of Author, Title of Book, Edition, Place of Publication, Publisher, Year of Publication, such as:

Labat, G. Regional Anesthesia. 1st ed., Philadelphia: Saunders (1922).

The names of all authors will be given in the first instance in each reference. In further references to the same authors the abbreviated form "Griffith *et al.*" may be used.

Illustrations

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Authors' price list and order blank for reprints will be sent with galley proofs. Order for reprints must be returned with galley proofs to the Editor; otherwise reprints cannot be furnished at these prices.

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